

Fermentation

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Living with kefir is difficult. I start with a few grains. There are not enough for the quantity of milk in the jar, and the kefir is watery. The grains keep growing. Now, the kefir is good. The grains keep growing. Only a day later, the kefir they make is too sour. There are too many grains in the jar. What to do with extra grains? The grains keep growing. I get a second jar. There is now too much kefir. I become irritated. The grains keep growing. They demand attention. They make me feel guilty. I can't throw living things down the toilet. Guilt makes me angry. I am now angry at bacteria that take care of me.

The theme of fermentation ties together emotional investment in some of the most intimate aspects of culture, such as food, with primeval biochemical metabolisms core to cellular life before the existence of the atmosphere; the politics of the food industry with the diversity of locations and cultures, many under threat of extinction; the genomics revolution and biology's fascination with bacteria with critical theory's de-centring of the subject, multispecies living, and an anti-fascist commitment to impurity. All in all, fermentation unites some of the most abstract scientific theories with personal politics, conceptual commitments and activism. This entry will consider some of these points while recognising that the fermenting topic itself will always exceed the vessel of a short text.

Making kefir, sauerkraut, miso, beer, wine and kombucha are practices of fermentation, i.e. working with bacteria and yeasts (fungus) to achieve a transformation in food or beverage, whether at home or on industrial scale. Used by humans from the Neolithic age, fermentation has a range of meanings: from a narrow definition in biochemistry that refers to anaerobic process of energy release to a wider use in food-making (or composting) which covers any microbial process, with or without oxygen. In strictly biochemical terms, the process of fermentation refers to the use of carbohydrates to produce energy without the presence of oxygen. With oxygen, the generation of energy starts with glycolysis, where glucose is converted into pyruvic acid that is used to generate adenosine triphosphate (ATP), which delivers energy to cells. Without oxygen, lactic acid is produced, which also leads to ATP. Fermentation, thus, is anaerobic respiration. Microbes and individual cells have the ability to switch between two different modes of respiration: the fermentation mechanism is present in cells in "higher" organisms. We feel the results of fermentation in our muscles when they ache from lactic acid produced during intense exercise.

Fermentation was the main method of energy-production before the presence of oxygen in Earth's atmosphere. It is the oldest "metabolic pathway" that unites eukaryotes (cells with nucleus enclosed within a nuclear envelope) and bacteria (prokaryotes without the envelope). Margulis and Sagan write, "When stressed, our bodies ... 'remember' the times before the atmosphere became suffused with oxygen. Such physiological flashbacks re-present past

environmental conditions and the bodies that evolved to live in them" (Margulis, Sagan, 1995, 66).

This capacity shared between prokaryotes and eukaryotes makes fermentation not only a process that occurs in the human gut, which should be attended to for healthy living, but also a lense for the form of attention that gave birth to the hypothesis of symbiogenesis. The collective work of its development from Konstantin Mereschkowski's proposal dating from 1905 to the labours of indomitable Lynn Margulis, whose paper was published in 1967 after multiple rejections, was widely supported only in the 1980s, after the development of quick DNA analyses, which showed that organelles of complex cells (like organs within a cell enclosed in their own lipid barriers) had different genetic signatures from those in cell nuclei (McFall-Ngai, 2017, M54). The theory of symbiogenesis claims that organelles in complex cells with nuclei were once independent bacteria (prokaryotes) before becoming assimilated into other organisms. Lynn Margulis's fascination with bacteria and work on the origin of eukaryotic cells changed contemporary biology and had a huge resonance in cultural theory (Margulis, 2002). It challenged linear evolution, the neo-Darwinian focus on competition as the driver of change and the classificatory impulse of reason running from Aristotle to Linnaeus and Whittaker's five-kingdom model. Emphasising the importance of cooperation in evolution and undermining essentialist ideas of autonomy and wholeness of species or individuals, endosymbiosis ("living together on the inside") inspired affect theory (Clough, 2008), work on gender and reproduction (Parisi, 2004), body theory, bioethics and the cultural analysis of chimerism (Shildrik, 2015).

The conceptual effervescence of contemporary biology in its focus on bacteria continues being a great resource for critical thinkers. One book that brings them together, *The Arts of Living on the Damaged Planet*, emphasises the importance of bacteria for life on earth, with nitrogen-fixing bacteria living in symbiosis with the roots of legumes feeding everyone, and sulphide-oxidising bacteria sustaining low oxygen marine environments. The genomics revolution allowed biologists to see that humans are literally made of microbes: at least 50% of cells in a human body are bacteria. Biologist Scott F. Gilbert presents a 6-point argument to demonstrate the difficulty in conceptualising animals as "individuals" (rather than holobionts - an "an organism plus its persistent communities of symbionts", M74): animals are not whole in terms of their genetic, immunological, anatomical, developmental, physiological or evolutionary individuality. Bacteria bring 8 million more genes to the DNA of the human body; they are key for body development, metabolism and the building of our immune systems. "We are multilineage organisms" (Gilbert, 2017, M83). Bacteria, thus, not only sustain life but also create an understanding of being that is profoundly porous, symbiotic, relational, cooperative and incomplete.

Work on bacteria, fungi and viruses is not only the preserve of biologists and critical theorists. Understanding the importance of bacterial and mycorrhizal fungi webs in topsoil (Puig de la Bellacasa, 2017) is foundational to indigenous and traditional knowledge and to movements such as permaculture (Mollison and Holmgren, 1978), do-nothing farming (Fukuoka), and the use of growing techniques such as agroforestry (forest gardening), urban and suburban permaculture, Hügelkultur (burying wood in growing beds) and many others. These are the

practices of living well with microbes. They extend from planting in gardens or guerrilla gardening with a view to bacteria, as well as to bees and other insects, to fermenting food in kitchens.

During my Soviet childhood in the 1980s, the time of various deficits, including of food, I ate large amounts of sauerkraut, gherkins and fermented tomatoes. In the autumn, my parents would ferment cabbage in 30 kg batches. It would last us through winter and spring, when vegetables and fruit were scarce. My family also made kvass (a non-alcoholic drink from fermented rye bread), cherry liqueur, and a tea drink that I only recently learned is equivalent to kombucha (it is known as Chainyi Grib, literally tea mushroom, in Russia). We also fermented apples and watermelons. In the kitchen, something was always brewing, accompanied by fruit flies. Growing food and preserving it by fermentation was a key element in sustenance across the territory of the Soviet Union. Love for some of fermented food is still strong. Kefir, which was obtained at the beginning of the 20th century from the Northern Caucasus and spread globally via Russia, is extremely popular, together with other fermented dairy and vegetables. However, as the great populariser of fermentation Sandor Ellix Katz reminds us, the barrier that separates fermentation from rotting is cultural (Katz, 2016, 2020). Practices of fermenting and aging marine mammal products in Chukotka (Bering Strait region of Russia and Alaska) were almost annihilated during the Soviet times when the smell and taste of such food appeared undesirable (Yamin-Pasternak et al. 2014). Here, indigenous, traditional knowledges are under the threat of extinction sharing the fate, if not of bacteria then of insects, fish, and other living beings. Fermentation can be enjoyed by connoisseurs lucky to live in areas with long-standing traditions of cheese, or of beer and wine-making, which appreciate unique strains of yeasts that only occur in the soils and plants of those regions (part of the concept of *terroir*) or can be deplored as disgusting when non-conforming to the dominant modern taste. With fermentation, however, even homogenisation is not linear: Swedes, for instance, love their fermented herring, *surströmming*, which is supposed to be one of the most pungent foods. While fermentation is a knot that ties together privilege and resources for taking care of one's health and *savoir vivre* with traditional practices of healthy survival under threat from intensive farming and fast food, there is no denying that fermentation is key to the art of living and eating.

While this entry is getting way too long, it is worth saying a bit more about fermentation, nutrition and food (see also Katz 2017). Fermentation preserves nutrients, but also breaks them into a more digestible form; it is a kind of pre-digestion (Mollison, 1993). Fermentation can reduce or eliminate toxic compounds found in roots, grains and legumes, which is especially important for equatorial Africa and Asia relying on cassava that can contain toxins. It creates new nutrients, including B vitamins, with ferments having anti-oxidant and anti-carcinogenic effects. Fermented foods boost gut microbiota, improving immune function and mental health. Katz mentions studies showing that live-culture foods improved infant survival rates in Tanzania and generally reduced diarrhoea episodes (Binita, Khetarpaul, 1998). While the whole world is undergoing "the nutrition transition" (Popkin et al., 2012), feeding on a global standard diet (Khoury et al., 2014), becoming fat and living fast (Popkin, 2009, Wilson, 2019), the knack of fermentation is going the way of other food habits - out of existence. Linking to the food justice

and social inequality concerns of food and fat studies, fermentation maintains heterogeneity - in bodies, cultures, environments - reorganising the ontologically-weighted distribution of the luck of being born and to live in a certain place, be of a certain ethnicity, gender and class.

Heterogeneity also includes ambivalence. Bacteria are not humans' benevolent angels. Apart from producing nutrients, vitamins and enzymes, fermentation also generates carbon dioxide and methane. The methane produced in cattle's rumen is a substantial contributor to global warming. The politics of food, animal rights, ecological activism and the business of laboratory-grown protein are also brought together by fermentation, but differently again. Fermentation is also not ontologically anti-capitalist: it is, for instance, core to the production of cacao and coffee - the beans of which ferment in the pulp of the fruit before being processed - and which are some of the key foods that drove colonial expansion and are amongst the most exploitative, inhumane and ecologically disastrous industries in the world.

A chemical process that unites the cells of my muscles with the making of vodka, fermentation seems to be in the middle of everything. Personal, political, biochemical, cultural, conceptual, activist, everyday, abstract, lively and deadly, - it is a perfect subject of the posthumanities.

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