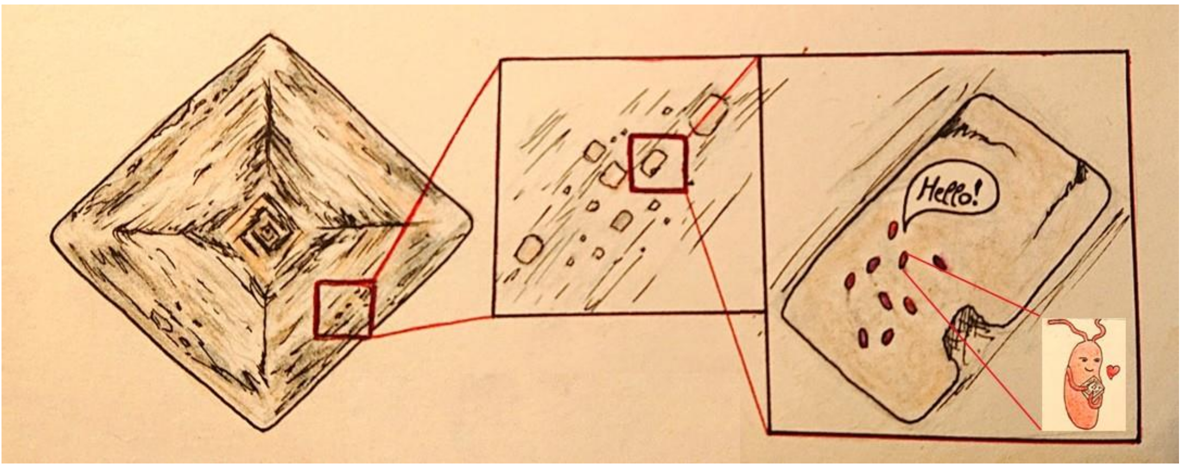
MicroChat

I am Sali: will you eat me today?

(*Kenneth Timmis and Terry McGenity*)

(with apologies: this is not really a chat but rather a monologue)



Sali living inside brine inclusions that are part of salt crystals (halite, NaCl) – image courtesy of Emese Bartha

Well, my real name is *Halobacterium salinarum* but you can call me Sali. I often live in salt crystals; the four walls of my home are made of salt (well, actually, there are more than four, but let's not get too technical). When you add salt to your chips, if chips are your thing, or other items on your plate, you not only add an extra dimension to their taste, you may be adding and eating me. When you eat me, I temporarily become part of your microbiome, specifically your gut microbiota. But I will not do you any harm and will sooner or later move on to other habitats or the afterlife.

But first I should explain a bit about salt and its importance for our bodies. Yes, salt is a key ingredient of food seasoning: a pinch of it sprinkled on our food improves its flavour. But no: we should not add too much as its taste becomes overpowering and we no longer detect the real flavours in our meals.

Now there are several different types of salt. My home consists mostly of sodium chloride, NaCl, the compound which we put on our food and which contains the elements sodium and chlorine. In water, sodium chloride usually exists as separate electrically-charged *ions* of sodium and chloride, which gives them the name *electrolytes*. Our blood and other body fluids contain rather exact concentrations of electrolytes, the main ones in blood plasma and between cells are sodium and chloride, that regulate all sorts of cellular and metabolic processes in our bodies. This is also why adding too much salt to our food is not good, can upset the electrolyte control of metabolic processes, and can give us health problems like high blood pressure. On the other hand, if we experience diarrhoea and lose a lot of fluid, we need to replenish not only the lost water but also our electrolytes, and so are often given an electrolyte mix to drink.

Too much salt is not only bad for us, it is also bad for most microbes, especially those that grow on fresh food and turn it bad. So adding lots of salt to raw food materials like cod, ham and table olives stops most microbes growing on them that would result in their deterioration, and hence increases their shelf life. Fresh cod goes off very quickly, in a few hours unless it is refrigerated, and even then does not last more than a few days. It starts to smell and taste bad. But salted cod lasts for ages and, after removal of most of the salt, tastes wonderful! Sometimes, extreme salt-loving microbes, including myself, can change the flavour-profile of salted foods and condiments, often improving their flavour and nutritional value, as with thai fish sauce.

And salt is sometimes used as a medicine: gargling with salt water is often recommended for people who suffer from throat infections. While salt water can soothe the throat, it is not known for certain precisely how. However, it is often stated that salt water inhibits pathogens, such as *Streptococcus*, and reduces inflammation, which fits with the fact that salt makes most bacteria feel unwell.

But where does salt come from? Salts mostly derive from rocks and rock formations on land. Rain washes them out by the processes of weathering and erosion, from which they are transported by rivers, groundwater and glaciers to the sea (https://oceanliteracy.unesco.org/ocean-salty/).

Water covers around 71% of the earth's surface, most of it in the sea. The sea's volume is regulated by inputs and outputs. Outputs include evaporation of water to the atmosphere, ice formation and percolation through sediments to subsurface aquifers. Inputs include rivers and water from underground, as well as precipitation (the return of the water evaporated to the atmosphere via rain or snow).

The open ocean has a salt concentration (salinity) of around 3.5%, with only subtle differences across the globe. Ocean salinity depends on the amount of water in the ocean, and the amount of salts delivered to the water. Its salinity has changed over space and time, as evidenced by huge deposits of ancient rock salt lying beneath seafloor sediments. If seawater or other sources of salty water are in a restricted area, like a lagoon or shallow basin (or, on a small scale, in a rock pool), then the rate of evaporation of water (output) may be faster than the input of new water, leading to the seawater becoming even more salty.

This process is encouraged by hot, windy and dry conditions, and may continue until salt minerals start to crystallise out of solution as solid salt. The process of crystallisation can be accelerated, for example, by diverting water from rivers to support agriculture. We see this happening today in the shrinking Dead Sea, which is saturated with salt (its salinity is about ten times that of seawater), so much so that sodium chloride forms crystals at its surface and on the seafloor, creating rock salt. Similar processes occurred over vast scales, with very large seas creating very large formations of salt. The salt deposits that are mined today were formed in just such a manner. To obtain the vast amounts of table salt for our food (and the chemical industry), we either mine ancient rock salt deposits, or coax seawater into shallow ponds or pans, allowing it to evaporate, creating sea-salt (https://doi.org/10.1016/j.palaeo.2006.03.044).

Well, that is enough salty chat: let's get back to our story and microbes, like me. As already mentioned, microbes in general do not like salty conditions, so when the salt concentration in a natural body of water increases, the microbial community changes. This results in the dominance of microbes that not only tolerate high concentrations of salt, but actually prefer living at extremely high salinity. The thousands of proteins in my cells, for example, have evolved to function under such high salinity. And as salinity increases even further, salt-adapted microbes like me can grow to such a high density that the brine in which we live becomes opaque and red, like tomato soup.

Salt pans in Aigues-Mortes, France. Mediterranean seawater is pumped into ponds, which increase in salinity due to evaporation. The orange salt pans are the most saline, and it is in these ponds that Sali and friends flourish and help to accelerate the precipitation of common salt (NaCl). *NASA Earth Observatory image by Lauren Dauphin, using Landsat data from the U.S. Geological Survey*. Below. Salinas de Torrevieja, Alicante, Spain

Now why do we turn salty water red? This is because we *are* red! Our colour comes from our production of lots of protective carotenoid pigments, similar to those found in carrots and tomatoes. These carotenoid pigments absorb radiation from the sun and warm up not only us but also the water, further encouraging its evaporation. So microbes like me actually accelerate the crystallization process. We have long been valued for our contribution to speeding up the process of making sea salt, even before anyone knew about us.

And, importantly, as sodium chloride precipitates, forming cubic crystals of halite, Sali and many friends living in the liquid become trapped inside the halite: we become imprisoned, shut off from the rest of the world!

Now I prefer to live in a salty liquid but when you see salt, you think it is solid. And most of it is. However, in halite crystals there are tiny pockets of salt-saturated liquid, called brine inclusions, and I live in these. They provide a safe liquid haven for me and other salt-loving microbes like me, preventing us from drying up. In terms of relative size, one microbe in a brine inclusion is equivalent to a water flea in a bucket of water, and there can be many hundreds of cells from different microbial species trapped inside a single brine inclusion.

For many reasons, I am one of the best at surviving under these conditions. For example, I can feed slowly off the microbes that were trapped in my cage when it formed and that subsequently died, and continue to grow when the oxygen runs out. I can hunker down – go to sleep/hibernate – and maintain just enough metabolic activity to stay alive, which means that I can even survive over geological time – millions of years. This lifestyle strategy means that if there is rainfall resulting in freshwater flow, which dissolves my solid salt cage and frees me from my prison, delivers nutrients and recreates a very salty water body, I am primed and ready to start growing again.

So when you eat your chips, think about me and my lifetime. When you eat the salt crystal, I might be inside it. Your saliva dissolves the salt and releases me from my salty cage. (When you gargle with salty water or add a splash of thai fish sauce to your food, I will have been released already). I may have been sitting in a salt crystal for years and, in some cases, for thousands or millions of years, just waiting to be released. I and my friends are witnesses to earth and biosphere processes over millennia.

Indeed, salt was such an important commodity to humankind that, while trapped inside salt crystals, we have participated – albeit passively – in all manner of historical events and processes, such as

- Roman soldiers receiving rations of salt as part of their salary (derived from the Latin for salt, *sal*; and the likely origin of the saying "being worth your salt"),
- Basque sailors taking salt on their voyages to preserve cod caught in far-off seas,
- numerous wars over salt supplies, and
- the French Revolution, for which salt taxation was a major grievance.

And, some of us, surviving in buried rock salt, have fascinating stories to tell about long extinct creatures, including dinosaurs.

So: when you eat me and my friends, you are eating history, very ancient history, because we have been there when both marvellous and calamitous events took place, and throughout the evolution of plants and animals.

https://seasalt.com/salt-101/about-salt/history-of-salt