Evolution – Culinary Culture – Cooking Technology

Thomas A. Vilgis

Fire and Cooking: the First Evolutionary Milestones

The history of humankind has always been, in addition to countless wars, a history of culture and scientific progress resulting in new technical possibilities. All people in all periods have had to eat in order to preserve the species. Food was and is a matter of survival.

Before the systematic use of fire, the food supply comprised raw foods such as raw vegetables, roots, berries, fruits, early vegetables, nuts, seeds, as well as birds' eggs and carrion as protein sources, carrion from animals killed by other predators.[1] Indeed, carrion, scavennging was despite aversion of great importance because meat and eggs, has supplied the early man with readily bioavailable nutrition down to the present: proteins and the amino acids they contain have always been essential for muscle development in humans.[2] Some early human species developed enzymes that facilitated alcohol consumption.[3] This expanded the food pallet, since this genetic modification also opened up another nutrition source: fermented, slightly rotten fruits and fermented vegetables. Another source of fermented food was the stomach contents of hunted or carrion animals. During gastrointestinal passage in ruminants, enzymes are present that can also break down cell materials such as cellulose into nutritionally valuable starch fragments and glucose. Pre-digested and hydrolysed proteins (split to fragments and essential aminoacids) also provided nutrients that were too valuable do without.

The human diet was thus clearly defined: Raw and fermented foods. Foods provided by nature that early humans only had to collect and perhaps

1 | See e. g. Kaplan, H. et al. (2000): A theory of human life history evolution: diet, intelligence, and longevity, in: *Evolutionary Anthropology: Issues, News, and Reviews*, 9(4), pp. 156–185.

2 | DeVault, T. L./Rhodes Jr, O. E./Shivik, J. A. (2003): Scavenging by vertebrates: behavioral, ecological, and evolutionary perspectives on an important energy transfer pathway in terrestrial ecosystems, in: *Oikos*, 102(2), pp. 225–234.

3 | Carrigan et al.: 2015.

clean off. Food was rare and finding it an essential strategy for "survival of the species". In order to eat and digest raw foods, humans had developed a different head shape, jaw muscles, greater intestinal length and intestinal flora over millions of years. Hard roots had to be chewed to obtain the nutrients they contained, it was only possible to break down and utilize the nutrient structures during longer gastrointestinal passages if ancient humans were equipped with an enzyme status and intestinal flora that were up to the task. A variety of germs, fungi and bacteria also contaminated all food, which was thus anything but "safe". Early humans had to rely on their taste buds. The species-adapted senses of humans and other animals provided the only way to test food for safety, edibility and nutritional value. Early humans obviously succeeded in all of this, since otherwise we would not be here today.

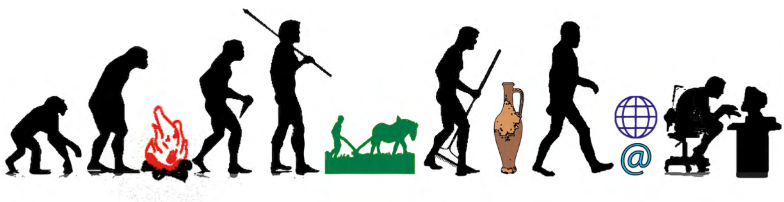

Fig. 1: Evolution (of cooking). From the first humans to hunters and gatherers to bloggers. The control of fire, development of agriculture and livestock farming, controlled fermentation and ultimately globalization and the "invention of the internet", were milestones in culinary culture.

A huge turning point came with the management and control of fire. For the first time in the nutrition of hominides, physico-chemical transformations were feasible. Foods were cooked, grilled and otherwise boiled. Their structure changed, foods were safe for the first time in the history of eating. Germs did not survive the cooking process. Therefore, the use of fire was the beginning of modern food technology and food processing. Control of fire was, in ethnological terms, the transition from "nature" to "culture".

New sources of food became available – what was not always edible raw could now be heated and consumed. Roots were made softer, inedible things edible, toxic substances sometimes toxin-free. Cooked food could be preserved somewhat longer, if only due to the resulting disinfection and reheated largely germ-free if the cooked food was not contaminated with fungal spores. At the same time, the food was also easier to digest. Meat and its proteins were denatured, hard plant cells burst to release micro-nutrients.[4] Macro and micro-nutrients were rendered more readily available; in physiological terms, less energy was required to break down

4 | Milton, K. (1999): A hypothesis to explain the role of meat-eating in human evolution, in: *Evolutionary Anthropology Issues News and Reviews* 8(1), pp. 11–21.

and digest the food. The energy balance for the (thermodynamically open) system "human being" improved further with the development of cooking techniques. Physiognomy and physiology showed adaptations.[5] The lower jaw receded somewhat, jaw muscles lost some strength, the intestines adapted to the new situation. The brain grew in response to the constantly increased energy supply due to the better yield.

Fire, Smoke and Embers

Control of fire also includes making use of smoke. Smoking and drying foods around the edge of the fire developed rapidly as methods of preservation.[6] Even rapidly perishable goods such as hunted meat could be dried. The resulting dehydration and reduced water activity reduced germ proliferation. It soon became evident how smoking on impacted the shelf life of foodstuffs, in particular highly valuable meat. Meat, which had to be hunted first, was suddenly preservable for a longer period of time. Food intake, and survival, became significantly more secure.

A number of new preparation techniques developed centred around fire. This required development of equipment, skewers, containers, cooking utensils, etc.[7] Cooking by grilling, boiling, in earth ovens, on and with hot stones or steam are among the early techniques that differ but little from the supposedly modern methods in use today, aside from accurate temperature control. Even low-temperature cooking became possible at some point. A leather-lined earthen pit was filled with water and the food to be cooked was placed inside while hot stones from the fire gradually heated the water.[8] "Gentle cooking", as such procedures are now called, is thus thousands of years older than profession now known as nutritional consulting. These examples clearly demonstrate how fire was always bound up with technical progress: cooking utensils, be they made of clay, later metal, or alternatives such as leather, and early hunting tools, were often directly related to the cooking techniques used at the time.

5 | McCully, K. S. (2001): The significance of wheat in the Dakota territory, human evolution, civilization, and degenerative diseases, in: *Perspectives in biology and medicine*, 44(1), pp. 52–61.

6 | Atalay, S./Hastorf, C. A. (2006): Food, meals, and daily activities: Food habitus at Neolithic Çatalhöyük, in: *American Antiquity*, pp. 283–319.

7 | Gauvain, M. (2001): Cultural tools, social interaction and the development of thinking, in: *Human development*, 44(2–3), pp. 126–143.

8 | http://www.rheinland-saga.de/RLS-Steinzeit-LebensraumGoennersdorf.html, last accessed February 24, 2017.

Early Cooking and Fermenting: Evolution of the Five Basic Taste Qualities

These consideratons imply also the function and meaning of the sense of taste.[9] The evolutionary process did not give humans this sense so that food critics sitting in starred restaurants could write their doggerel, but rather each of the five tastes – sweet, sour, salty, bitter and umami – is deeply rooted in the evolutionary development of humans.[10] The primary tastes reflect a profound relationship between the function of the cells comprising all biomaterials and the function of the physiology of biomaterials. Molecular cell function and taste have a common evolutionary denominator. Of course seasoning food with sweetness, salts or glutamate was not around early in the history of mankind, but the sense of taste did provide orientation, particularly in the case of the two extremes bitter and sweet, on which basis poisonous and edible are quickly differentiated. There has never been a food that is both sweet and poisonous (although imprecise and populistic sources have tried to characterize sugar in this way). Every food with a slightly salty taste, rock salt, a mixed crystal of the cations sodium, calcium, magnesium and the corresponding anions (mainly chloride), and many (vegetable) products from salted water, have always been good for the mineral balance in the diets of humans and other animals.

Taste quality	Cell function	Evolutionary function	Trigger
Sweet	Glucose, energy	Non-toxic	Glucose, fructose, glycosides
Sour	Regulating pH, Information transfer	Salivation, safe food (pH <5)	Protons
Salty	Switching function with multivalent ions	Physiological mineral balance	Sodium, calcium; magnesium
Bitter	Antioxidants, cell damage	Warning against poison	Phenols, polyphenols
Umami	Building blocks for muscle cells	Targeted protein intake	Glutamic acid, aspartic acid Nucleotides

Cooking and fermenting led us to perceive of the taste umami – tasty, savoury.[11] This taste is triggered by "glutamate", glutamic acid, and rein-

9 | See for different perspectives Le Magnen, J. (1985): *Hunger* (vol. 3), Cambridge and Hladik/Pasquet/Simmen: 2002.

10 | Mather: 2006.

11 | Kurihara: 2015.

forced by two nucleotides, the two phosphates inosine monophosphate and guanosine monophosphate, which are derived from cytometabolism. In fact, the amino acid glutamic acid is a very prevalent component of every protein. The umami taste is therefore geared to amino acids, i. e. essential amino acids, and thus guided humans to protein-rich foods. This was the only way our muscles and brain could develop as they have done. The development and character of this primary taste was crucial to human development.

It was quite natural that glutamic acid was selected as the main actuator in the umami sense: It is the most frequently occurring amino acid of all, is not essential, is in part enzymatically transformed in the metabolic process into another amino acid, glutamine, it is heat stable, does not undergo any Maillard reactions and is therefore always available, even in grilled meat, and last but not least does not react chemically to produce "harmful" products. Every time something is stewed or roasted, and every time bread is baked, the taste experience centres around glutamic acid, and thus umami. What was eaten during the evolution of Homo sapiens was controlled by umami and the other tastes. Umami, sweet, slightly salty and slightly acidic were the guarantors of human-oriented nutrition. These five tastes allowed humans to become what they are: an omnivorous species able to find food in different living situations and environments and under different climatic limitations. This is exactly what evolution theory teaches us.

Cooking as a Cultural Achievement

Human culture begins with the control of fire and conscious exploitation of it. Fire is also the decisive key to what separates humans from other animals – a fact that is often forgotten. No other species on earth is capable of using fire consciously and with foresight, for example with the intention to cook food. Studies have shown repeatedly that certain species of apes use tools and prefer precooked food to raw food, but no other species has mastered fire. It may sound trivial from our current perspective, but fire from whatever source, be it flames or burning rods in nuclear power plants, is still the line that separates humans from other animals, nature from culture. These ideas led the ethnologist and cultural scientist Claude Lévi-Strauss to the concept of the culinary triangle on which he founded culinary structuralism.[12] They defined the aspects raw, cooked and rotten or fermented to describe the transitions between nature and culture on one axis, and from unchanged to changed on the other. Cooking is thus also assessed as a cultural achievement (a point denied relevance in many discussions).

12 | Lévi-Strauss/Weightman: 1994.

The Culinary Triangle: Cultural and Physical Structuralism

Raw is thus defined as the original structure, for example the crisp apples just fallen from the tree, fresh carrots covered with soil, living animals or René Redzepi's seafood, still alive when served. Each further process, even washing the carrots, salad or apple is already, according to the definition in the cultural sciences, a "cultural act" leading away from the original "raw" state. If "the raw" is left to nature, without cultural interventions, it rots. Cultural measures, by "cooks", make it possible to control the rotting process, which is then known as fermentation. Cooking and fermenting are therefore to be honoured as basic cultural acts dedicated to the continuation of life.

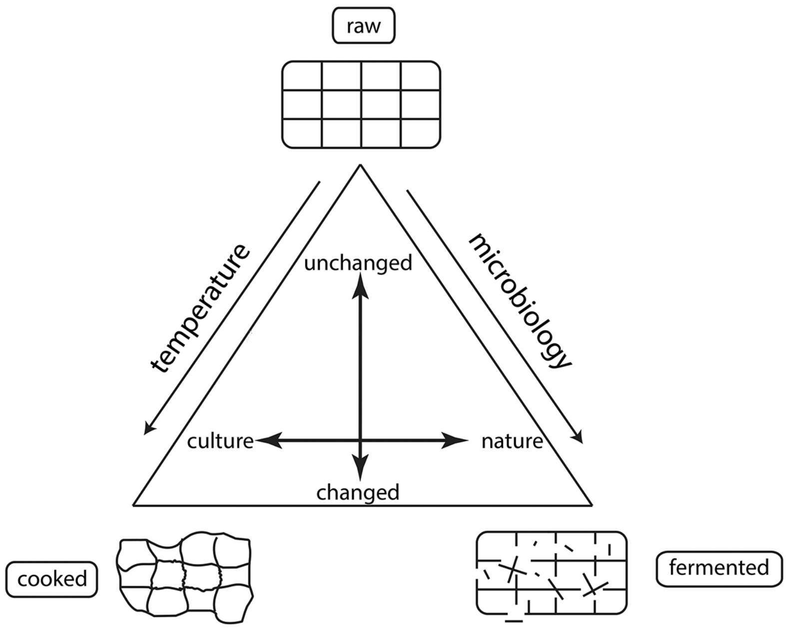

Fig. 2: The culinary triangle according to Lévi-Strauss (inner) expanded by adding the symbolism of the molecular processes (outer). The human transition from nature to culture was only possible through control of temperature and microorganisms (Vilgis 2013b).

The abstract considerations on which the culinary triangle is based can be scientifically justified by taking into account the changes in molecular structures brought about by specific process techniques.[13] The techniques of fermenting and cooking involve different processes. Cooking is usually done by changing typical "thermodynamic" parameters such as temperature, pressure, or volume. At the fire, or on the stove or grill, it is always

13 | Vilgis: 2013a/2013b.

the temperature that is changed. The first changes are the modifications in protein structures, altering the texture of the food. The focus is on physical changes in the food items. Fermentation always involves the participation of micro-organisms, e. g. lactic acid bacteria, yeasts, etc. This initially facilitates enzymatic chemical reactions. The changes at the molecular level are of a different nature. Thus the natural science interpetation of the culinary triangle yields a strong link between cultural and natural sciences.[14]

In fact, down to this very day these cornerstones of food preparation have remained unchanged. Despite modern techniques and technological progress, the methods of preparation learned and defined in the early years of evolution, the basis of food consumption remains the triangle formed by the basic states raw, cooked and fermented. The molecular structure of foods stipulates these possibilities and allows for no others. So it is not surprising that all food transformations, whether through cooking, fermenting or methods that takes a different initial approach, can all be located within the culinary triangle. In the end, all that counts is the condition of the food, which can only be defined at the level of its molecular parameters.

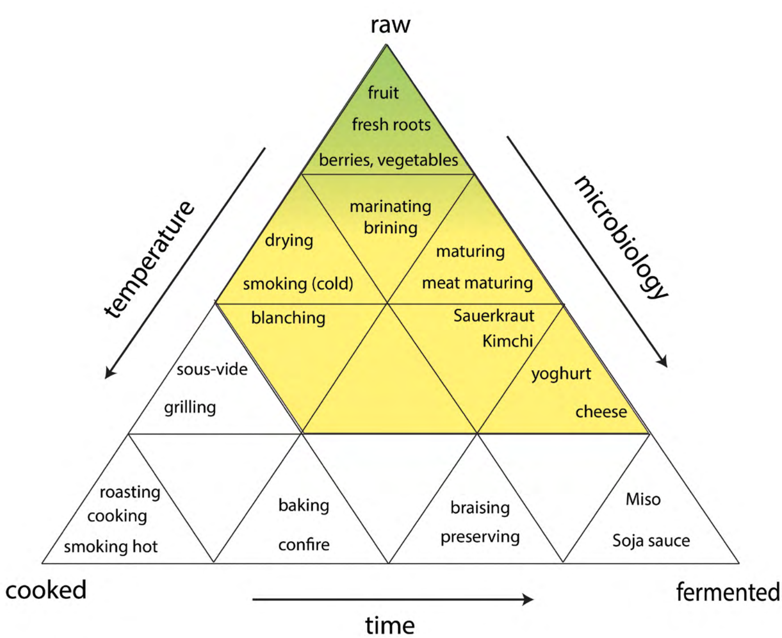

Fig. 3: The culinary triangle contains all of the preparation techniques so far developed by humans. A distinction between "old" techniques and "modern techniques" is not absolutely necessary from a "structuralist" and natural scientific point of view. Pseudo-raw (shaded area) reflects cultural acts such as washing or cleaning, whereby the molecular structures do not change significantly, but ethnologists categorize these acts also under "cooking" (Vilgis and Tzschirner 2014).

14 | Vilgis: 2013a.

Thus both old and new techniques are found within the culinary triangle. These molecular aspects, together with the knowledge of the molecular processes, result in many new perspectives. It is obvious, for example, that long cooking as in stewing or fondue will produce a molecular structure in the end that is thermodynamically similar to what is produced by complete fermenting, for example as in miso pastes or soya, fish, or oyster sauces: a predominantly "hydrolysed" status. Proteins and other food ingredients are disassembled for the most part. This can be tasted on the tongue: The state "fermented/hydrolysed" in the culinary triangle is covered for the most part by the primary taste umami. The shows once again how and why cooking and fermentation techniques have continued to evolve until today, be it in the first leavened recipes, lactic acid fermentation or Greco-Roman garum.[15]

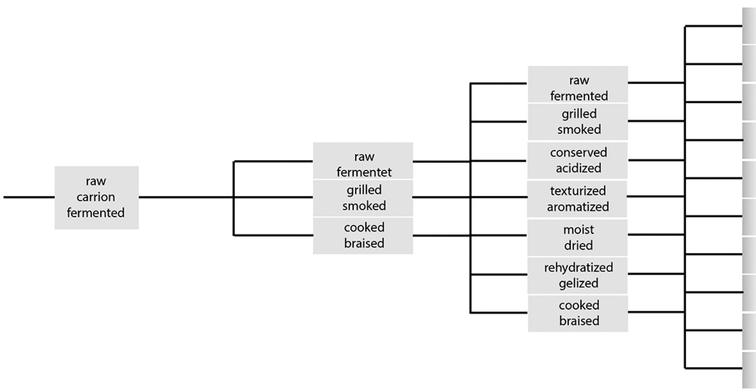

Fig. 4: New techniques do not alter the basic principles of cooking. They simply establish finer subdivisions in the physico-chemical parameters and facilitate a finer, more precise taste perception – as well as enhanced complexity of the dishes served (Vilgis 2013a).

Another aspect is of great importance: The culinary triangle does not reveal per se whether a cooking technology is "old" or "new". In fact, the old cultural techniques remain the foundations of modern cuisine. All that is "new" are the execution and technical possibilities. The diversity of nuances, textures and flavours is growing, and this variety allows us to create dishes with extreme complexities of taste. Nevertheless, the old techniques remain basically unchanged, since this basis is controlled by molecular processes. Even this aspect of the history of culinary culture is reflected in the scientific view of the culinary triangle.

15 | Corcoran, T. H. (1963): Roman fish sauces, in: *The Classical Journal*, 58(5), pp. 204–210.

All Roads Lead to Umami

These different cultural and processing techniques can be described clearly and understandably by the basic molecular changes (here the example of proteins) in the culinary triangle.

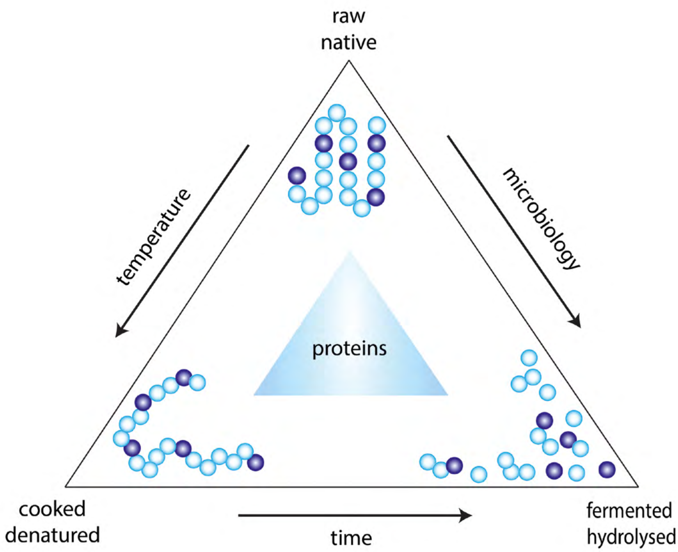

Fig. 5: The culinary triangle as a "triangle of states" for proteins during the cooking and fermentation process. The hydrolysed state is the result of the cooking process and of the fermentation. Long cooked foods thus have modified taste "umami" and please with "kokumi" as well as the fermented state.

In the primary raw state, the molecular components of food are present in their native form, proteins, chain molecules of individual amino acids (shown as balls) are "folded", and retain their original structure in most cases. The "raw" becomes the "cooked" by raising the temperature. The "thermal energy" unfolds the proteins, which lose their structural form, altering the texture of the food. When foods are fermented by the agency of micro-organisms that release enzymes, the proteins are gradually broken down into pieces, until individual peptides and amino acids are released, including glutamic acid (dark blue). This results in "umami", whereas some small fragments of two or three amino acids account for "kokumi" (mouth-filling sensation) if they are still carrying a glutamic acid. Fermented sauces, fish sauces, soy sauces (as well as Maggi-type seasonings) are therefore always umami, savoury and mouth-filling. Long cooking, as in gravy or sauce stocks results, after denaturing, in protein fragments and free glutamic acids, and therefore also in umami and kokumi. This is also the case in cooking stocks, broths, stews. Long cooking splits proteins, producing umami, savoury and mouth-filling sensations, as in fermented sauces and miso pastes. Different approaches, different cultures, one goal: the depth of good taste.

Here and Now

Things changed when globalization led to a general dissemination of foodstuffs. Regional borders, seasonal limitations, harvest failures are problems of the past for the (Western) world. Above all the internet and social media such as Facebook allow for immediate dissemination of information in words and pictures for the first time in the history of mankind. The Spanish cuisine revolution triggered by Ferran Adrià (2014), the avant-garde cuisine, or the term "molecular cuisine" used by journalists showed this clearly: Videos and links have made it possible for anyone to call himself or herself a "molecular cook". The thickeners and gelling agents can be ordered using the same medium, with instructions in words, images and videos on the internet it was not surprising that even non-cooks mutated temporarily to "molecular cooks". The taste was mostly secondary, the effect was what counted. It has to be noticed: copying has never before been practised in such volume and so rapidly as in these times of Facebook, Instagram and blogs.

Cooking trends are also manipulated, pushed and spread via the web. The noise about this is louder and more fundamental than the realization will ever be: veganism, paleo-nutrition, detox, eternal health. What is forgotten in all these irrational hubbubs are the basic functions of food: nutrition, survival, enjoyment. Media such as television and the internet show prosperity and its dark shadow at the same time: abundance. In fact, abundance is a potent adversary of cooking culture. Everything is available all the time, mass convenience.

Harking back to the past makes logical sense, but it's also a specious game. Today, regionalism is celebrated as though it were the ultimate new trend. But we must not delude ourselves. These principles are ancient. This was the ultima ratio of bygone food culture, food history, born of need and deprivation. All one had to eat was what could be culled from the immediate natural environment within the narrow confines of the present. Fermenting and smoking were not practised primarily for the test, but rather to preserve foods as a basis for survival. Such preserved foods would help alleviate the always impending shortage of food. The media hype on all this is basically exaggerated. This becomes clear when we consider the hype on "dry-aging" and "nose-to-tail". These expressions sound new and chic for the moment, but what lies behind them is anything but new. These are also ancient methods, in particular "nose-to-tail" and "root-to-flower". In earlier times it was unthinkable to hunt an animal, then eat only the rack meat from the back. Everything edible had to be eaten, not necessarily for ethical reasons, but because there was always just enough to go around. Ethical aspects were first brought into play by the founders of religions and philosophies, not in the face of hard facts and technological progress. Hunger is the best cook. In times of need, food on the table certainly precedes morality. Humanity had to earn reversing these values – first morality and then food. Only a satiated society can afford this attitude, and it is not only overproduction that has got out of hand. If one shops among producers on the market square, instead of in the anonymous (organic) supermarkets, one learns a lot about the products and the relevant cooking techniques: the real farmer's wife (and not the one depicted on tinned food by marketing managers), can explain the principles of using entire vegetables, give long-forgotten tips and involve anyone interested in a culinary dialogue that is more valuable than 1000 clicks and Facebook comments.

The Alienation and Deculturalization of Food

Rarely has the culinary world seen a greater alienation of culinary culture than in these fast-paced days. The "orgies" of the Roman Empire and the excesses of the Middle Ages may show a certain degree of decadence. The generations that have grown up in our time of affluence and overabundance, have never learned product-adjusted cooking techniques. It was easy to develop a sense of disgust for innards, tripe and pigsheads. These things need not be cooked and eaten at all if lying next to them are a selection of lean steaks ready for the pan at downright ridiculous prices: vacuum-packed, anonymous, the immediate animal origins just barely recognizable. Stoveside creative challenges are no longer necessary, new taste experiences are no longer possible.

On the other hand, a lot of technology is invested in vegetarian alternatives to derive quasi-meat from the "tofu animal". Vegan "sausages", vegi-meat and vegi-fish from plant and insect proteins as replacements for more natural sources? Such reconstructed foods are counter-evolutionary and perplexing: If we were to present in this book a recipe for a green, fresh salad made from meat we would be laughed at or driven off to the madhouse. On the other hand, markets and prizes for futuristic developments are showered on products comprising meat from plant protein, hydrocolloids, aromas and flavourings. A few years ago they called this kind of convenience products artificial analogue "cheese" made from cheap ingredients. If the first wise ones around the fire hundreds of thousands of years ago had foreseen such things, they just might have decided to put the fire out again.

Unfortunately, nowadays we keep forgetting how fundamentally important the development of culinary culture was, and still is. It was along our mastery and control of fire and micro-organisms that made possible the diverse and environmentally compatible achievements of humanity in technology, art and culture. It now seems absurd to buy "paleo-food" (or what people think nowadays is paleo-food) in the supermarket and carry it home in the boots of our high-powered motor vehicles? Novel invented terms such as "vegan paleo-smoothies" ignore the great cultural achievements of humankind completely.