Molecular Gastronomy? Please don't confuse with molecular cooking

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Whereas a new group of Molecular Gastronomy is created in Finland, we celebrate 20 years of activity of the discipline, created in 1988 by the late Nicholas Kurti (1908-1988), former professor of physics in Oxford, and by one of us (H. This).[1] At that time, it was observed that whereas the science of food composition and the study of industrial processes were very well developed, many daily preparations were not being considered by food sciences. In particular, very little work had been devoted to food transformation during cooking, as simple statistics shows: in the "Meat" chapter of the famous *Food Chemistry* textbook,[2] less than 0.5 % of the chapter presented scientific data useful for interpreting culinary transformations, and the "Wine" chapter contained absolutely nothing about cooking wine in spite of a very frequent use of wine in meat cooking.

The creation of Molecular Gastronomy was then appropriate, but as it was realized in the beginning of the 2000's, the initial program of the discipline was badly structured, as it mixed science, technology and communication. The application of new knowledge produced by science is of course important, but these two activities are different, and in the idea of the two founders, Molecular Gastronomy is science, not technology.

For short, let us admit that science is, for short, the activity of looking for the mechanisms of phenomena, using the "experimental method", also called "hypothetico-deductive method". In this regard, any phenomenon needs an "explanation": the surge of mountains, the blueness of the sky, the behavior of subatomic particles… and the rise of soufflés, the softening of carrot roots during thermal processing ("cooking") in water or the change of color of immature pods of green beans during heating. These last examples bring us directly to the core of "Molecular Gastronomy", a scientific discipline created

And now

After 20 years of development of the discipline, where are we and what are the key issues?

From 1988 to 2000, the initial mixed program nevertheless generated a culinary trend called "Molecular Cooking", or "Molecular Cookery", whose definition is "using new tools, new ingredients, new methods". Of course, such a definition is flawed, as what was "new" in the 1980's is no longer new today, but it is a fact that Molecular Cooking is very different from earlier ways of cooking, as it uses tools adapted from those used in laboratories, such as sintered glass filters, rotary evaporators, ultrasonic probes, etc., and uses compounds that were not used before in kitchens (sodium alginate, calcium lactate, total phenolics from grape juice, flavours, ascorbic acid…).

The educational applications of Molecular Gastronomy were also important, as whereas chemistry is suffering some disaffection, Molecular Gastronomy, which is largely chemistry, is attracting students. This may in part be because they can see more directly some "practical interest" to science, and also as a result of the more "positive" vision that it gives of chemistry. For example, for very young kids, some "science and cooking" sessions propose to make one cubic meter of whipped egg white with only one egg, as for older students, the maximum volume is calculated. At the same time, both kinds of students understand why whipped egg whites are white and firm, whereas egg whites are yellowish and air colorless and transparent.

A new program

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[1] Hervé This, *Let us have a simple experiment, in memorial, Nicholas Kurti –(1908-1998)*, in *The Chemical Intelligencer*, July 1999, p. 47-48.
[2] Belitz, H. D.; Grosch, W. *Food Chemistry*; Springer: Heidelberg, 1999.

After 2000, when the confusion between science, technology and communication was noted, a new scientific program for Molecular Gastronomy was proposed. At the same time it was realized that any culinary recipe is composed of three parts: some technically useless information, a "definition" of the dish, and "culinary precisions"; this latter category encompassing old wives tales, proverbs, tips, methods, and more generally technical details added to the definition. For this reason, the new program of Molecular Gastronomy is: (1) exploring the definitions (modeling) and the culinary precisions (collection, tests, analysis); (2) exploring the "art" component of cooking; (3) exploring the "social link" component of cooking.

Some additional information has to be added here, in particular to justify the objectives 2 and 3. First we propose to recognize that we do not eat "food", but rather "dishes", as even for a simple "carrot salad" the root of *Daucus carota* L. has to be washed, peeled, but in thin threads, and immersed in a dressing; during all this preparation process, some phenomena arise, so that the "dish" is different from the root in the field. Indeed, Molecular Gastronomy is devoted in particular to all these preparation steps that transform food ingredients into dishes. The technical aspect is not enough, also, as cooking is producing "good food": food is no food when it is not consumed. This has a consequence, i.e. that we have to explore (scientifically, using the "experimental method") what "good food" means. This particular line of study goes along with a scientific study of the "social link component" of cooking: it was recognized in 2003 that dishes are not only nutriments, but materialization of cultural needs.[3]

Tools for science

Of course, as any science, the ambition in Molecular Gastronomy is to discover new mechanisms of phenomena. Because culinary transformations involve both physical and chemical phenomena, two kinds of studies are done.

As culinary transformations induce physical modifications of the microstructure of dishes and also changes of the chemical content of the various compartments composing the dishes, physical and chemical analyses are needed.

As most food are based on thermally processed plant or animal tissues, in isolation or in water (stocks, broths, sauces…), the chemical modifications at the surface or inside such tissues are to be followed. For chemical analyses, dishes components being complex systems, fast analytical methods are needed. When possible, of course, a minimum modification of samples is required, as in other fields of metabolomics.[4] Interpretations of such analysis, with a large quantity of data, needs chemometric methods.[5] For example, during recent studies of the evolution of the pigment content of immature pods of *Phaseolus vulgaris* L. ("green beans") [6,7] or during a time course study of the composition of aqueous solutions obtained by thermal treatment of roots of *Daucus carota* L. ("carrot stocks"), [8] we had to use multiple linear regression methods in order to interpret the phenomena. More

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[3] Hervé This, Cooking, a quintessential art, California University Press, Los Angeles, 2008.

[4] Anne Cazor, Hervé This, Sucrose, Glucose and Fructose Extraction in Aqueous Carrot Root Extracts Prepared at Different Temperatures by Means of Direct NMR Measurements, Journal of agricultural and food chemistry , (2006), 54, 4681-4686

[5] M. Cuny, G. Le Gall, I. Colquhoun, M. Lees, and D.N. Rutledge. Fruit juice authentication by 1H NMR : Discrimination between grapefruit juice, orange juice and blends thanks to chemometric tools. Analytica Chimica Acta, (2008) 390:419–427

[6] Juan Valverde, Hervé This. 1H NMR quantitative determination of photosynthetic pigments from green beans (*Phaseolus vulgaris* L.), Journal of Agricultural and Food Chemistry, (2008), 56(2), 314-320

[7] H. This, A. Cazor, D. Trinh (2008). Color Evolution of Aqueous Solutions Obtained by Thermal Processing of Carrot (*Daucus carota* L.) Roots: Influence of Light. Journal of Food Science, (2008), 73 (4), E176–E182

[8] Anne Cazor, Hervé This, Sucrose, Glucose and Fructose Extraction in Aqueous Carrot Root Extracts Prepared at Different Temperatures by Means of Direct NMR Measurements, Journal of agricultural and food chemistry, (2006), 54, 4681-4686

information could be extracted using other methods such as ACI.[9] These investigations reveal organic processes in aqueous solution, so that such model studies are both important for the understanding of cooking, but also for making compounds in a "green approach".

In order to follow microstructural modifications (that determine bioactivity of food molecules), one has to consider that most dishes components are colloidal systems, so that analytical methods for studying such physical systems are needed: of course, when possible, methods giving information directly, without sample preparation, should be used, such as neutron beams, X-rays, but also confocal microscopy/image analysis or nuclear magnetic resonance imaging. With these informations, formula from the so called CDS/NPOS (Complex Disperse Systems/Non Periodical Organization of Space) formalism can be established; [10] it aims at giving a spatial description of not only food, but also all colloids, as are most formulated products. Culinary transformations being dynamic processes, time course evolution of formulae are the objective. In practice, complex gels are at the core of the activity, because plant and animal tissues are formally gels, with a liquid phase dispersed into a solid, continuous phase. Of course, other analytical methods such as NMR, various microscopies (optical, fluorescence, UV, IR, confocal, etc.), but also various methods for separation (EC, HPLC, GC-MS…) and identification (mass spectrometry) can be used, to give more detailed descriptions of changes.

Both chemistry and physics field meet when the relationship between matter transfers and chemical modifications of transported compounds are considered. In particular many interesting studies can be devoted to the analysis of "matrix effects", based on the idea that the bioactivity of molecules (nutritional, sensory, toxic… properties) present in dishes is not given by composition tables, but indeed determined by the physical and chemical environment of the molecules, including time course release, or supramolecular associations, [11] for example. Pigments are important systems that molecular gastronomy can study, along with taste molecules, odorant molecules, toxic molecules.

Comparative Molecular Gastronomy?

As more groups of Molecular Gastronomy are created in various countries, we can now envision that each country can focus its study on the particular definitions and precisions, so that we can look forward to a time when "Comparative Molecular Gastronomy" will be possible. Of course, some assumptions on the origin of such precisions can be made on the basis of "robustness of recipes", but a more comprehensive collection of culinary precisions associated with periods would help to investigate such cases.

Dozens of thousands of culinary precisions were collected for French culinary books only, but it would be scientifically interesting that other countries than France do the same work, as it would allow some comparative works. The CDS/NPOS formalism also could be useful: in the same was as it was used for studying the evolution of the number of physical categories of sauces, it could be applied for comparing sauces between countries, and understand cultural influences and transfers.

This would also have educational interest, perhaps helpful in view of the current pandemic of obesity. Even in Creta, where originated the famous Cretan diet, up to one third of children age 12 years old are now overweighed or obese![i] Another important data is the increasing concern for environment, and the increasing proportion of the population living in cities. Energy issues are also to be considered. And, finally, there is a growing gap between the world of science and the laypeople, along with the disaffection for scientific studies.

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[9] H. This, A. Cazor, D. Trinh (2008). Color Evolution of Aqueous Solutions Obtained by Thermal Processing of Carrot (*Daucus carota* L.) Roots: Influence of Light. *Journal of Food Science*, 2008, 73 (4) , E176–E182 doi:10.1111/j.1750-3841.2008.00724.x

[10] Hervé This, Formal descriptions for formulation, International Journal of Pharmaceutics (2007), 344(1-2), 4-8

[11] H. This, J.-M. Lehn, Chimie supramoléculaire et auto-organisation, Pour la Science, 2001, 290, 80-85.

All these data lead toward the idea that children should receive more information about food and food preparation. In particular, health programs promoting healthy diet cannot be successful if people cannot choose cleverly the food they eat. In order to adapt food to particular cases, citizens need to get some clear information about it. But tradition is no guarantee for healthy food, and for rational preparation of food. This is why *Ateliers expérimentaux du gout*[ii] and other programs were introduced in France, linking cooking and science, at school. Some of these programs include field work of children that contribute to the collection of culinary precisions, in order to create a national data base of such precisions. No doubt that others countries could do the same.

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[i] Eurobesity, (2002), http://www.iotf.org/aboutobesity.asp.
[ii] This H., (2001), Les Ateliers expérimentaux du gout, *Presses de la Sorbonne* (also http://crdp.ac-paris.fr/index.htm?url=d_arts-culture/gout-intro.htm).