AN INTRODUCTION TO MOLECULAR GASTRONOMY AND ITS TERMINOLOGY

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He was a bold man that first eat an oyster.
— Jonathan Swift

Abstract: *Contemporary culinary practice seems to have abandoned the idea of food as a cultural and identity marker, lost its symbolism of rootedness heading toward culinary frontiers, seeking the new and strange and overturning conventional expectations for flavour and presentation. The newly emerged techniques, tools and ingredients should be designated using a term other than nouvelle cuisine, which is no longer reflecting the realities in the field of haute and experimental cuisine. Even though the emergence of molecular gastronomy as a science is relatively new, the concept of using food chemistry techniques to study food and cooking dates back to the 18th century. However, the concept was formalized and the term was coined in 1988 by two scientists, the Hungarian physicist, Nicholas Kurti and the French physical chemist, Hervé This. The latter admitted that the terminology associated with the newly created field is commonly misused. The aim of this article is to bring together and to analyse the related terms that might create confusion.*

Keywords: *food science, molecular gastronomy, terminology.*

Nouvelle Cuisine. Art and Craft of Cooking

Contemporary culinary practice has exceeded all expectations. Some particular modern dishes seem to have abandoned the idea of food as a cultural and identity marker, lost its symbolism of rootedness heading toward culinary frontiers, seeking the new and strange and overturning conventional conceptions about flavour and presentation, as Benjamin Aldes Wurgaft writes in a review on one of the latest cooking styles.

According to Spence and Youssef (2018), the newly emerged techniques, tools and ingredients should be designated using a term other than *nouvelle cuisine*[1], which is no longer reflecting the realities in the field of haute and experimental cuisine.

> There is widespread agreement that what some of the most innovative chefs have been doing over the last quarter century or so in the west deserves a name that highlights how things have moved on in the kitchens and dining rooms from the *nouvelle cuisine* movement. However, what no one can seem to agree on is what name should be given to this movement. The scientists and press have been keen to label it as the science of 'molecular gastronomy'. However, many of the top chefs, after in some cases initially embracing the idea, have distanced themselves from that moniker. In their pronouncements and interviews, the latter

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[1] A modern style of cooking that avoids rich, heavy foods and emphasizes the freshness of the ingredients and the presentation of the dishes. https://www.dictionary.com/

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> have been keen to stress that while they are interested in the findings of scientific research, what they do is better conceptualized as the art and craft of cooking.

The new term should indicate the close connection, the interference of scientific research in culinary practice. Moreover, the new gastronomic trends are influenced by the fine arts such as painting and music.

> Many of the top chefs have been inspired by the results of the scientific research much as they are inspired by what is happening in many other fields of endeavour, from painting to jazz etc. Given that it is mostly not what the chefs do, it becomes increasingly unclear whether 'molecular gastronomy' is itself anything more than a 'glorified' sub-discipline of food science. [...] the most appropriate name for what distinguishes contemporary culinary practice is what can be labelled 'experimental cooking'. It is defined as much by its innovativeness, its novelty, its creativity, and by the way in which it engages with the diner's intellect and emotions (with the diner's brain in other words), as with their gut.[1]

Defining Molecular Gastronomy

Gastronomy was defined by Jean-Anthelme Brillat-Savarin (1825, apud Yek and Struwe) in the *Physiology of Taste* as, "everything connected with the nourishment of man." All modern dictionaries define it as "the art or science of good eating/ the art and practice of choosing and preparing and eating good food"[23]

Molecular gastronomy is sometimes referred to as *culinary alchemy* - a precursor of food chemistry but with fewer scientific roots. Even though the emergence of molecular gastronomy as a science is relatively new, the concept of using food chemistry techniques to study food and cooking is far from modern. In the eighteenth century, Marie-Antoine Carême, a famous French chef, was an early molecular gastronomer who wrote carefully detailed essays about culinary pleasures, fusions of ingredients and functional techniques. It was not until the close of the twenty-first century and the years that followed that the integration of food technology with the culinary arts became a justifiable field of study in its own right. [4]

> Today, many food writers and chefs, as well as most gourmets, agree that chemistry lies at the heart of the very finest food available in some of the world's finest restaurants. At least in the world of gourmet food, chemistry has managed to replace its often tarnished image with a

[1] Spence, Charles and Jozef Youssef, Assessing the long-term impact of the molecular gastronomy movement on haute cuisine, in *International Journal of Gastronomy and Food Science*, Volume 14, December 2018, pp. 35-44, https://www.sciencedirect.com/science/article/pii/S1878450X18301069

[2]Yek, Grace S. and Kurt Struwe, *Deconstructing Molecular Gastronomy,* 2008, http://www.kitchen-theory.com/wp-content/uploads/2011/10/Deconstructing-Molecular-Gastronomy.pdf

[3] https://www.thefreedictionary.com/gastronomy

[4] Marcus, Jacqueline B., MS, RD, LD, CNS, FADA, *Food Science Basics: Healthy Cooking and Baking Demystified in Culinary Nutrition*, 2013, https://www.sciencedirect.com/science/article/pii/B9780123918826000029

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growing respect as the application of basic chemistry in the kitchen has provided the starting point for a whole new cuisine. [1]

From the scientific perspective cooking can be viewed as molecules obeying well-known processes that describe the behaviour of all solids, liquids and gases. The application of chemistry and other sciences to restaurant and domestic cooking is thus making a positive impact, but this activity consisted mainly in small collaborations between scientists and chefs. However, the reactions that make food taste good or bad are still not very well understood. Nevertheless, there have been many novel applications of existing science, producing exquisite dishes and extending the range of techniques available in their kitchens.[2]

The term *molecular gastronomy* is credited to the Hungarian physicist, Nicholas Kurti and the French physical chemist, Hervé This. *Molecular Gastronomy* was first formalized as a concept by the two scientists in 1988. They applied *food science* to explain and solve culinary issues, bringing the tools and technology that are widely used in the *food industry* to the restaurant kitchen.

In an interview, Herve This, who was asked about the confusion between the terms 'molecular gastronomy' and 'molecular cooking' concluded: "there is a lot of confusion between Molecular Gastronomy, Molecular Cooking or cookery[3], and such chimeras as 'culinary science' or 'scientific cooking'. Generally, the confusion is based on the fact that people don't know what gastronomy is, what science is, and even in scientific circles, there is a confusion between science and technology, or engineering".[4]

Consequently, *molecular gastronomy* explores the physical and chemical phenomena occurring during culinary transformations, i.e. dish preparation and consumption (This and Kurti, 1994; This, 2002, 2006, apud Burke, This and Kelly, apud Snitkjaer, 2009). To summarize, it is the science of cooking or more generally the science behind a good meal. This involves scientific investigation of preparation techniques as well as the study of cultural and social factors affecting diner's perception of the meal.[5]

Related Terms. Food Science

The *food industr*y is characterized by more formalized and defined procedures, but when it comes to a professional chef or a domestic cook, there are many steps followed when preparing food, many of which traditionally regarded as 'anecdotal' from a scientific

[1] *Molecular Gastronomy: A New Emerging Scientific Discipline*, Peter Barham, Leif H. Skibsted, Wender L. P. Bredie, Michael Bom Frøst, Per Møller, Jens Risbo, Pia Snitkjær, and Louise Mørch Mortensen, Chem. Rev. 2010, 110, 2313–2365

[2] cf. *ibid.*

[3] The act of preparing something (as food) by the application of heat
https://www.thefreedictionary.com/cooking

[4] https://www.kitchen-theory.com/defining-molecular-gastronomy/

[5] Snitkjaer, Pia, *Investigations of meat stock* , 2009, pp. 1-9
http://www.kitchen-theory.com/wp-content/uploads/2011/10/Investigations-of-meat-stock.pdf

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point of view. It seems that this was one of the main reasons for transforming 'Molecular Gastronomy' into a scientific discipline.[1]

It is distinct from the traditional *food science*, which is focused on food production on an industrial scale. *Food science* explores the biochemical, biological, chemical, physical and physiochemical properties of foods and beverages,[2] or as the Institute of Food Technologists (IFT) defines it, *food science* is "the discipline in which biology, physical sciences, and engineering are used to study the nature of foods, the causes of their deterioration, and the principles underlying food processing"[3]. It developed in close collaboration with the food industry in the 19th and 20th century. Its role has been to provide safe and nutritious food for the masses in the most efficient and economical manner possible (Fuller, 2001; Roudot, 2004 and Struwe, 2008, apud Snitkjaer, *op. cit*.), whereas the phenomena occurring during cooking have been neglected (This 2007, apud Snitkjaer, *ibid.*).

On the other hand, *food technology*, which is the application of *food science*, is defined as "the application of food science to the selection, preservation, processing, packaging, distribution, and use of safe, nutritious, and wholesome food" (IFT)[4]. Still, neither the science nor the technology is focused on the study of restaurant cooking processes or the creation of new dishes in the kitchen, a position that has been filled by *molecular gastronomy*.

Until the establishment of *molecular gastronomy*, there was also no scientific discipline studying the chemical processes of cooking at home or in the restaurants – as opposed to food preparation for the mass market.[5] As opposed to traditional *food science*, molecular gastronomy examines the scientific basis for the quality and sensory experience of foods produced in small amounts that will be consumed relatively quickly and close to the place of production (van der Linden et al. 2008, apud Snitkjaer, *ibid.*).

Although considered by some researchers to be distinct from *food science*, in the abstract of their work *Molecular Gastronomy: An Introduction*, Burke, This and Kelly (2016) claim that "In the world of *food science*, *Molecular Gastronomy* is a term which is relatively new, but describes the convergence of the two long-established core food disciplines, i.e., food science and the art of the chef." It basically is the food science behind cooking, as Jacqueline B. Marcus points out when referring to the ultimate goal of molecular gastronomy: "By discovering the *food science* behind cooking, *molecular gastronomy* is able to explain why some recipes fail and others succeed and which ingredients and techniques are optimal."[6]

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[1] Burke, Roisin, This, Herve and Alan L. Kelly, *Molecular Gastronomy: An Introduction*, Reference Module in Food Science, 2016
https://www.sciencedirect.com/science/article/pii/B9780081005965033849

[2] cf. Marcus, Jacqueline B. , *Culinary Nutrition, The Science and Practice of Healthy Cooking*, 2013, p. 52

[3] http://www.ift.org/knowledge-center/learn-about-food-science/food-facts/about-fs-and-t.aspx

[4] *Ibid.*

[5] https://splice-bio.com/molecular-gastronomy-the-food-science/

[6] Marcus, Jacqueline B., *op. cit.*, Chapter 2 - *Food Science Basics: Healthy Cooking and Baking Demystified: The Science behind Healthy Foods, Cooking and Baking*
https://www.sciencedirect.com/science/article/pii/B9780123918826000029

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However, in contrast with traditional approaches of *food science* and technology, which considered mostly the chemistry, physics, or biology of food ingredients and industrial transformations, the focus of molecular gastronomy is on phenomena occurring during the preparation of dishes. Applications building on the principles of *molecular gastronomy*, such as 'Molecular Cooking' and 'Note-by-Note cooking'[1] have emerged in recent years. Food scientists, culinary scientists, food engineers, and chefs are increasingly collaborating within these areas, whether in the kitchen or in industry.[2]

Note-by-Note Cooking/ Cuisine

Another term that has created a stir is *note-by-note cooking/ cuisine,* coined by This in his book published in 2014 (*Note-by-Note Cooking: The Future of Food*). *Note-by-note cuisine* is a style of cooking that replaces traditional ingredients such as meat and vegetables with their chemical constituents. [...] it relies solely on chemicals while still using classic and molecular cooking techniques.[3] This new way of cooking is meant to add unadulterated nutritional value to dishes of all kinds, actually improving upon the health benefits of so-called natural foods. The use of molecular compounds will be more energy efficient and environmentally sustainable than traditional techniques of cooking. Its founder considers it an important phase in culinary evolution on which the long-term survival of a growing human population depends. Although it was initially rejected by This, the idea of *scientific cooking* seems to take shape in the form of his *note-by-note cooking*.

In the review of This's book, Benjamin Aldes Wurgaft quotes the gastronome Brillat-Savarin: "Tell me what you eat and I'll tell you what you are" and reconsiders this connection in terms of traditional and note-by-note cuisine.

> Today I might answer, "I ate a hard-boiled egg for breakfast, with a little pepper," but if I were This, himself an enthusiastic purveyor of Brillat-Savarin quotations, I might answer, "I ate a solidified combination of ovalbumin (the globular protein in the white), water, lipids, and other proteins (in the yolk), flavoured with piperine as well as various terpenes for odour." If Brillat-Savarin was right about an intimate link between our food and our identities, what is each of us, the one with the egg and the other with the ovalbumin? Are we the same kind of eater? Many contemporary food subcultures are driven by this same logic of identity, and many eaters love to know about the origins of ingredients, to hear that the *jook* or the *hotteok* or the pig cheek tacos they're consuming are "authentic," as if they'll too become more authentic by eating them. Molecular gastronomy and note-by-note cooking take a different tack. They abandon the identity principle and its symbolism of rootedness, head toward culinary frontiers at warp speed, seek the new and the strange, and delight in overturning conventional expectations for flavour and presentation. Nothing composed in such a way can claim great "authenticity," and none of the recipes described in This's book resemble anything my grandparents ate.

[1] **Note by Note cuisine** is a style of cooking based on molecular gastronomy, created by Hervé This. Dishes are made using pure compounds instead of using animal or plant tissues. https://en.wikipedia.org/wiki/Note_by_Note_cuisine

[2] Burke, Róisín , This, Hervé and Alan L. Kelly, *op. cit.*

[3] https://www.cnbc.com/2018/06/29/note-by-note-cuisine-can-boost-food-security-herve-this.html

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Food Engineering

Boom and Jansen (2014) note that

> Although the increased affluence has given one more concern about health, it also had the positive effect that consumers worldwide have more time and resources to spend on high-quality food. Dining in a restaurant is now common everywhere, whereas media pays much attention to sophisticated food, through television shows, often with famous chefs, who have become celebrities. The increase in popular interest for the systematic understanding of the changes in foods during preparation, led to the emergence of molecular gastronomy and gastronomic engineering (e.g., This, 2002; Aguilera, 2011). These are new branches of food engineering that explicitly aim at the creation of new sensorial experiences in a restaurant setting (i.e., not foods that are stored over time, but products that are created and immediately served to the consumer). Here, good understanding of the underlying molecular and mesoscopic[1] processes taking place in the food, while being prepared, gives an enormous scope to create innovative textures with various ingredients.

Food engineering, which became an academic discipline in the 1950s, is a professional and scientific multidisciplinary field related to food manufacturing. As Barbosa-Canovas and Juliano (2005) explain, it covers the practical applications of *food science*.[2] Its purpose is to advance the implementation of efficient industrial processing in the transformation of raw materials of biological origin into edible forms, which includes packaging, storage, and distribution. The current research areas require expertise in materials science, applied mathematics and modelling and biochemical engineering applied to foods.

Second, *food engineering* includes the study of engineering properties (e.g. compositional – boiling or freezing point; physical - size, shape, volume, density; mechanical – compressive strength, sensory – texture and colour, thermophysical – specific volume, heat, etc.) New processes recently discovered by food engineers are the isolation of gelling agents for the spherification of juices, or the availability of protein isolates from various sources that can be used to form new textures. It has provided better understanding of the processes taking place within a food matrix during preparation, such as the realization that crispiness is related to the glassy state (which created the possibility to have crispy slices made from vegetables, or even liquids).[3]

As defined by Aguilera, *gastronomic engineering* (GE) means using the vast body of knowledge accumulated in food engineering and food materials science to propel the curiosity and creativity of chefs to what is technologically feasible and environmentally sustainable. GE opens new opportunities for *food engineering*, a discipline that has been

[1]Pertaining to a size regime, intermediate between the microscopic and the macroscopic, that is charact eristic of a regionwhere a large number of particles can interact in a quantum-mechanically correlated fashion.
McGraw-Hill Dictionary of Scientific & Technical Terms, 6E, Copyright © 2003 by The McGraw-Hill Companies, Inc.

[2] cf. Barbosa-Canovas, Gustavo V. and Juliano P., *Food engineering: encyclopedia of life support systems*, 2005 https://unesdoc.unesco.org/ark:/48223/pf0000143332

[3] cf. Boom and Jansen, *ibid.*

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mostly oriented to the food processing industry. Aimed not at very large-scale production but at the creation of individual products, it brings *food engineering* closer to the homes of individual consumers.[1]

Molecular Gastronomy Techniques

The different molecular gastronomy techniques give rise, in most cases, to an opaque terminology. The most common of these techniques are: spherification, gelification, emulsification, transformation and sous vide.[2]

1. Spherification is the most commonly seen molecular gastronomy technique. It uses chemical reactions to "trap" liquid ingredients with an extremely thin, tasteless membrane, forming clear "beads", which look like pearls or caviar eggs. The technique is based on the reaction between calcium chloride and alginate, two substances that when mixed together gel together.[3]

2. Emulsification. Foams, or 'airs' are used in molecular gastronomy to add an extra touch of flavour, an almost ethereal quality to a dish. A hand blender is used to mix the ingredient of choice with soy lecithin. An emulsifier derived from soybeans, lecithin has little flavour so it will not affect the taste of the foam. The applications are endless, from balsamic foam to put over strawberries, to a citrus air to top a margarita cocktail, to the inventive chive foam.[4]

3. Sous vide is the technique of slow cooking meat under a water bath, at low even temperatures (55 to 60 °F), and for an extended period of time. Such molecular gastronomy techniques have existed since the late 1700s, but were lost over time and only rediscovered in the mid-1960s. Sous vide requires special equipment, most specifically a "sous vide machine" or some type of immersion circulator.[5]

4. Gelification relies on jellifying agents like Agar Agar or Carrageenan. The purpose is to turn liquids into a more solid state. This allows the cook to serve what are typically liquid dishes in a new, more solid and unpredictable format. For this technique, the gelling agent is mixed with the liquid ingredient (e.g. tomato soup or papaya juice) and brought to a boil, then later passed through a clear silicone tube (to achieve the spaghetti shape) under an ice bath.[6]

5. Transformation (Transglutaminase). Although it sounds less than appetizing, one of the best and most fun molecular gastronomy techniques uses something known as "meat glue",

[1] https://www.sciencedirect.com/science/article/pii/B9780444525123000607

[2] Top Molecular Gastronomy Techniques and Recipes
https://www.gourmetfoodworld.com/molecular-gastronomy-techniques-15249

[3] **e.g**. Honey Caviar with Fourme D'Ambert and Black Tea by Quantum Chef of MolecularRecipes.com

[4] **e.g.** Broiled Mussels with Chive Foam by Popartichoke.com

[5] **e.g.** Sous Vide Steaks by J. Kenji Lopez-Alt of Seriouseats.com

[6] **e.g.** Papaya Agar Agar Noodles by Jason Logsdon of ModernistCookingMadeEasy.com
Peanut Butter Powder & Jelly Noodles by Mira Mi of Mirauncut.com

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known also by its technical name, transglutaminase, a tasteless enzyme that can bind together protein-rich foods like meats.[1]

In conclusion, *molecular gastronomy*, which has become a discipline in its own right, describes the convergence of the two long-established core food disciplines, i.e., *food science* and the art of the chef. *Molecular gastronomy,* which is also a branch of *food engineering*, explores the physical and chemical phenomena occurring during culinary transformations, i.e. dish preparation and consumption; generally, it is the science behind a good meal. This involves scientific investigation of preparation techniques as well as the study of cultural and social factors affecting diner's perception of the meal.

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[1] https://www.gourmetfoodworld.com/molecular-gastronomy-techniques-15249

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