

# Molecular Gastronomy Techniques

**Unit:** Culinary Science

**Problem Area:** Food Science

**Lesson:** Molecular Gastronomy Techniques

- **Student Learning Objectives.** Instruction in this lesson should result in students achieving the following objectives:

- 1 Describe molecular gastronomy science.**
- 2 Summarize molecular gastronomy techniques.**
- 3 Describe the chemistry and physics of molecular gastronomy additives, supplies, and equipment.**

- **Resources.** The following resources may be useful in teaching this lesson:

E-units corresponding to this lesson plan. CAERT, Inc. <http://www.mycaert.com>.

“Balsamic Vinegar Pearls Recipe,” *Modernist Cooking Made Easy*. Accessed Oct. 8, 2014. <http://www.modernistcookingmadeeasy.com/info/modernist-recipes/more/balsamic-vinegar-pearls-recipe>.

*Molecular Gastronomy Network*. Accessed Oct. 8, 2014. <http://www.moleculargastronomynetwork.com/>.

“Stabilizing Whipped Cream,” *Cook’s Illustrated*. Accessed Oct. 8, 2014. [http://www.cooksillustrated.com/how\\_tos/8351-stabilizing-whipped-cream#](http://www.cooksillustrated.com/how_tos/8351-stabilizing-whipped-cream#).

Wetzelberger, Lisa. “A Beginner’s Guide to Molecular Gastronomy,” *Pinterest*. Accessed Oct. 8, 2014. <http://www.pinterest.com/pin/108649409732426107/>.

“What Is Molecular Gastronomy,” *MolecularRecipes.com*. Accessed Oct. 8, 2014. <http://www.molecularrecipes.com/molecular-gastronomy/>.



## ■ Equipment, Tools, Supplies, and Facilities

- ✓ Overhead or PowerPoint projector
- ✓ Visual(s) from accompanying master(s)
- ✓ Copies of sample test, lab sheet(s), and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

## ■ Key Terms. The following terms are presented in this lesson (shown in bold italics):

- ▶ agar-agar
- ▶ collagen
- ▶ colloids
- ▶ dehydration
- ▶ effervescence
- ▶ emulsification
- ▶ fizz
- ▶ flash freezing or nitrogen freezing
- ▶ foam
- ▶ food science
- ▶ froth
- ▶ gastronomy
- ▶ gelification
- ▶ molecular gastronomy (MG)
- ▶ polysaccharide
- ▶ siphon whipping
- ▶ sous vide
- ▶ spherification
- ▶ surfactants
- ▶ xanthan gum

## ■ Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

*Ask your students: What comes to mind when you hear the term molecular gastronomy? Have them brainstorm terms, thoughts, guesses, and examples of molecular gastronomy. Record the brainstorming session. Use VM-A in your discussion. Then add more descriptions to the brainstorming list.*

*Access the short video at <http://www.molecularrecipes.com/molecular-gastronomy/>. The video is in the section, “The Possibilities Are Endless.” After*

watching the video, conduct one more brainstorming session, and add additional words to describe molecular gastronomy.

You could create a flipped classroom homework assignment as an introduction to molecular gastronomy prior to using this lesson. Students would complete the video introduction to molecular gastronomy before this lesson is presented. Then create a flipped classroom viewing guide—three to five questions per video—for student use while they are “watching their homework.” A series of molecular gastronomy videos, by *Enthusio Chefs*, is available at [https://www.youtube.com/watch?v=Dw1\\_toPxXSQ&list=PLcAZT9-T52Q17MsDr8o-culUCuw1sy4d0](https://www.youtube.com/watch?v=Dw1_toPxXSQ&list=PLcAZT9-T52Q17MsDr8o-culUCuw1sy4d0). This series has 35 videos; you would need to select six appropriate videos.

## CONTENT SUMMARY AND TEACHING STRATEGIES

**Objective 1:** Describe molecular gastronomy science.

**Anticipated Problem:** What is molecular gastronomy science?

- I. Molecular gastronomy and how it works
  - A. **Gastronomy** is the art or practice of selecting, cooking, and eating “good” food. Most food writers and expert chefs say that gastronomy is a term that indicates a form of respect for the art of preparing and serving food. Over time, some foods fall out of favor and, as a result, new foods are invented. The molecular gastronomy trend adds “science” to the art of selecting, preparing, serving, and enjoying food. However, the true gourmet—no matter the type of food trend—prefers quality to quantity and constructs meals with artful pairings (drinks and accompaniments). The opposite of a gourmet is a glutton.
  - B. **Molecular gastronomy (MG)** is the study and application of the physics and chemistry that take place during cooking. MG encompasses the art and the science of selecting, preparing, serving, and enjoying food. It is food on a microscopic level: a sub-discipline of food science characterized by avant-garde (experimental) cooking techniques. Molecular gastronomists study the chemical-physical processes that take place when food is cooked. Food science is different than MG. **Food science** is the analysis of the chemical makeup of food and the development of processes for industrial applications. Some innovations from MG are blood orange foam, transparent ravioli, hot ice cream, and fried mayonnaise. Restaurants around the country have adopted the trend to transform flavors and presentations. MG combines food science and culinary arts to transform ingredients into trendsetting modern cuisine. Molecular gastronomy is sometimes referred to as molecular cuisine or modern cuisine.

1. MG is a trend in haute cuisine.
2. U.S. cities that have numerous MG restaurants are Chicago, San Francisco, and New York City.
3. MG uses avant-garde cooking techniques and equipment to liven up and change flavors and serving presentations with emulsification (foams and froths), gelification, spherification, and sous vide.
4. The focus of MG is to create a multisensory dining experience.
  - a. MG may combine unusual flavors. MG uses the term “juxtaposition” (placing two or more substances close together for contrast) to describe one of its most important rules. For instance, some MG chefs pair a flavorful food with a less flavorful food as a contrast, or they combine two dominant flavors (e.g., chocolate and raspberry) for a decidedly rich taste.
  - b. MG may manipulate textures (e.g., foam, dust, and gel).
  - c. MG may make theatrical presentations (e.g., fizz, froth, and vapor).
  - d. MG may use chemistry lab equipment to create unexpected dishes (e.g., liquid nitrogen flasks, vacuum sealers, cream whippers, and siphons).
  - e. MG may manipulate food with additives (e.g., agar-agar and calcium alginate).
5. MG uses high-tech equipment and chemicals to create physical and chemical transformations during cooking that make food unique.

#### C. How MG works

1. Chemists sort all matter into three groups: elements, compounds, and mixtures. Elements (e.g, carbon, hydrogen, and oxygen) cannot be broken into other substances. Compounds (e.g., water, table salt, and water) are made of two or more distinct elements joined chemically in a specific proportion. For example, water is two parts hydrogen to one part oxygen (H<sub>2</sub>O). Mixtures are combinations of substances that are not held together chemically. They can be separated by physical means (e.g., filtering and sediment).
  - a. Food dishes are mixtures known as colloids.
  - b. **Colloids** are materials composed of tiny particles of one substance dispersed, but not dissolved, in another substance.
2. Examples of how MG colloids work:
  - a. Type: Foam  
Description: Gas dispersed in a liquid  
Example: Whipped cream and beverage foams
  - b. Type: Solid foam  
Description: Gas dispersed in a solid  
Example: Marshmallows
  - c. Type: Gel  
Description: Solid dispersed in a liquid  
Example: Gelatin and jelly

- d. Type: Emulsion  
Description: Liquid dispersed in a liquid  
Example: Mayonnaise, milk, and cream
  - e. Type: Solid emulsion  
Description: Liquid dispersed in a solid  
Example: Butter and cheese
3. MG chefs and restaurants merging science with culinary arts include:
- a. Grant Achatz, Chef, *Alinea*, Chicago, IL
  - b. Jonas Halstead, Chef, *1515 Restaurant*, Denver, CO
  - c. Dominique Crenn, Chef, *Atelier Crenn*, San Francisco, CA
  - d. Bruno Chemel, Chef, *Baumé*, Palo Alto, CA
  - e. Todd Erickson, Chef, *Haven*, Miami Beach, FL
  - f. Rob Evans, Original Chef, *Hugo's*, Portland, ME
  - g. Michael Voltaggio, Chef, *Ink.*, Los Angeles, CA
- D. MG safety
- 1. MG uses no synthetic chemicals.
  - 2. MG uses biological chemicals from plants and animals in small amounts that meet standards for human consumption.

**Teaching Strategy:** Many techniques can be used to help students master this objective. Use VM–A. Also, show this video: <http://www.molecularrecipes.com/molecular-gastronomy/>. Students could conduct research about one or more of the MG chefs and restaurants and present their findings to the class. Then use VM–B through VM–D for illustration purposes.

**Objective 2:** Summarize molecular gastronomy techniques.

**Anticipated Problem:** What are common molecular gastronomy techniques?

- II. Molecular gastronomy techniques: the science
- A. **Dehydration** is the process of drawing moisture out of food to preserve it and/or to dry its surface. Most consumers are familiar with dried tomatoes, crispy banana chips, and fruit leathers. Molecular gastronomists use dehydration in a different way. Food is preserved and used for its crunchy or crispy texture and intense flavor (e.g., crispy sheets, dusts, and flavored powders). Dehydration occurs when warm, dry air is circulated around food to crisp and/or to preserve the food for another or a later use. Dehydrating food is conducted in a commercial dehydrator (a series of slotted disks holding food onto which warm, dry air is circulated) or in a restaurant or home oven.
  - B. **Emulsification** is the technique that turns liquid into a light air-foam. It incorporates and stabilizes air bubbles in a liquid mixture. Typical additives that create emulsifications are soy lecithin and methylcellulose (also called

surfactants). **Surfactants** are surface-active agents that reduce the tension between the water and air surface to stabilize the air and the foam. [NOTE: Dish detergent is a type of surfactant. It reduces the tension between baked-on food and the pot, pan, or baking dish surface to help release food particles.]

1. **Foam** is an emulsification process that develops froth from liquids. Foam traps air bubbles in temporary emulsions. (They are temporary emulsions unless stabilized with whipping equipment or with the addition of gelling or thickening agents.) Examples of foams are meringues and homemade marshmallows (an example of solid foam). Air bubbles are trapped in a liquid and are turned into a foam mixture with agitation. In MG, emulsification incorporates and stabilizes the air bubbles in a liquid. A person can simply whisk air into a mixture to create foam, but this process is unstable and will soon deflate. An emulsifier added to the foam acts as a barrier between air and water to stabilize mixtures. Gelatin, agar-agar, and xanthan gum are replacements for fat molecules in heavy cream.
2. **Froth** is a cooking term referring to a layer of foam consisting of tiny bubbles or the process used to achieve them.
3. **Siphon whipping** is the creation of a foam mixture without the addition of an emulsifying agent. The product of siphon whipping is called “espuma,” which is the Spanish word for foam. Culinary gourmet whippers have been used for many years to make whipped cream and Chantilly cream (e.g., iSi cream whips with N<sub>2</sub>O cartridges). The heavy cream is poured into the whipper along with flavoring and powdered sugar. Then the nitrous oxide cartridge (N<sub>2</sub>O) is inserted into the device, and the gas is released in the bottle. Pressurized gas bubbles penetrate the fatty liquid (heavy cream). As a result, the volume of the cream increases. The powdered sugar contains some cornstarch to stabilize the mixture and prevent deflation of the whipped product. Next, the mixture is allowed to hydrate for about 20 minutes. Finally, the device is turned upside down. Then whipped cream is deposited onto desserts, coffee beverages, etc. The volume obtained in the cream whipper is greater than the volume a person can obtain with a wire whisk or hand mixer.
4. Stabilizing freshly whipped cream is a related emulsification process. To prevent fresh whipped cream from deflating after 3 hours, the following steps should be taken:
  - a. It is necessary to start by adding ½ teaspoon unflavored powdered gelatin into 1½ tablespoons water. After it stands for 3 minutes, it can be placed in the microwave for 5-second intervals until dissolved. The unflavored gelatin stabilizes the liquid. Food dishes created with unflavored animal gelatin are stable to 99°F.
  - b. It is essential to begin whipping 1½ cups chilled heavy cream with 1½ teaspoons granulated sugar and ½ teaspoon vanilla. The gelatin mixture should be added slowly until soft peaks form.
5. **Fizz** is a bubbling feeling on the tongue due to concentrated carbon dioxide (CO<sub>2</sub>). As the bubbles burst in the mouth, a pain response is triggered from the nerves in the tongue and mouth. The nerve response intensifies the food aro-

mas and flavor. Without carbonation, for instance, beverages taste bland. Carbonation of fruits can be accomplished in a soda siphon or in an iSi cream whip device.

- a. **Effervescence** is a chemical reaction that results in the escape of gas from a body and the foaming or fizzing resulting from the release of the gas. A common example is the carbonation in soft drinks. The common additive to create effervescence is popping sugar. Popping sugar (Pop Rocks) is, simply put, sugar that contains carbon dioxide. Once the popping sugar melts, usually from coming in contact with moisture, a popping sensation is felt in the mouth.
  - b. A simple effervescent mixture (a mixture that bubbles) can be made with one part baking soda, one part Fruit Fresh or crushed vitamin C tablets, and two parts powdered sugar. The effervescent mixture should be added to the dry skin sides of cut apples or pears. It can be dusted on toffee candy. The fizzing sensation is a combination of sodium bicarbonate (baking soda), citric acid (an ingredient in Fruit Fresh), and water (saliva when tasted).
  - c. The powdered sugar is added for sweetness and to counteract the bitter taste of baking soda.
- C. **Flash freezing or nitrogen freezing** is “cooking” with liquid nitrogen that quickly freezes any food it touches at  $-321^{\circ}\text{F}$  ( $-196^{\circ}\text{C}$ ). In cooking, liquid nitrogen is a coolant. As the liquid nitrogen “boils away,” it gives off a thick nitrogen fog (vapor cloud) that adds drama to food preparation and presentation. Liquid nitrogen is transported in special flasks and is dangerous to the skin. An anti-griddle is an alternative to liquid nitrogen. At  $-30^{\circ}\text{F}$  ( $-34^{\circ}\text{C}$ ), it looks like a cooktop but does not heat food. It instantly freezes sauces and purées on the outside while the interior remains a creamy, thick liquid. Liquid nitrogen creates an instantaneous vapor cloud that results from the condensation of ambient air. It cools the food, causes a vapor (fog), and then evaporates. The denser the food, the colder it will become (and the longer it takes for the liquid nitrogen to evaporate). [CAUTION: The extreme cold of liquid nitrogen makes handling dangerous. Training is required prior to use to understand reactivity and burn risk. Aprons, gloves, and other specially designed safety gear are best used when handling liquid nitrogen. It is not an ingredient, so it is not consumed. It cools the food and then evaporates. Food should be eaten *after* the liquid nitrogen is *fully* evaporated. Also, foods cooled with liquid nitrogen are extremely cold and must “warm up” before eating.]
1. When a liquid food is cooked by submerging it into nitrogen, the outside of the liquid food will be solid while the inside remains liquefied.
  2. Alcohol, which normally does not freeze, can be made into a sorbet with nitrogen.
  3. An advantage of flash freezing to regular freezing is that flash freezing creates smaller ice crystals. Large ice crystals distort the product’s structure, but flash freezing leaves more of the original cell structure intact. So ice creams prepared with liquid nitrogen are extremely smooth because of the small ice crystals formed with flash freezing.

- D. **Gelification** is the molecular change of a liquid food to a solid, gel-like food. MG gel types include pearls, ravioli, and spaghetti shapes. Liquids are converted to solids with the addition of a gelling agent. Traditional gels are found in flours, tapioca, cornstarch, eggs, and gelatin. Gelling agents typically are dry (powders and sheets) and need to be hydrated (take up water or another liquid). Gelification occurs when a substance (e.g., agar-agar and unflavored animal gelatin) stabilizes a liquid. MG food dishes created with agar-agar are stable (do not melt) up to 185°F. Food dishes created with unflavored animal gelatin are stable to 99°F.
1. Gelling agents come from nature. Some are agar-agar (used in commercial puddings, candy, and soups), gelatin (used to make Jell-O), carrageenan (used in commercial chocolate milk and salad dressings), and pectin (used to make jelly). **Collagen** is the structural protein in the connective tissue of animals. It is extracted from meat byproducts (e.g., bones, hides, and hoofs) and is used to manufacture gelatin.
  2. Gelification occurs in many refrigerated cooked meats and fish. The small amount of liquid turns to a gel around the meat when it is refrigerated.
  3. The general steps to creating a gel are dispersion, hydration, and formation.
    - a. Dispersion is distributing the gelling agent throughout the liquid. The gelling molecules must be completely surrounded by water to separate the powder particles, and it must be stirred enthusiastically to disperse the molecules. Gelatin molecules stick together and form lumps when the molecules are not well dispersed.
    - b. Hydration adds water (or another liquid) to the gel molecules. This causes the molecules to be suspended in the solvent (liquid). Typically, it requires heating to properly hydrate the solution.
    - c. Formation occurs after hot hydration and the temperature dropping to a gelling temperature. Some gels form at room temperature, and others form under refrigeration.
- E. **Sous vide** (French for “under vacuum”) is a technique that involves sealing food in an airtight plastic bag and cooking it in a water bath for several hours on low heat. Sous vide allows food to retain moisture and flavor. Food is vacuum-sealed in airtight plastic and is cooked in a water bath for a longer time than normal. Some sous vide machines circulate the water, and some do not. Circulation speeds the cooking time. Vacuum-packing food and immersing it in a hot water bath changes the physics of cooking. Because the temperature control is so precise, the core temperature is reached within a half-degree, so overcooking is close to impossible. Vacuum packing prevents air from insulating the food, increases food safety, and slows oxidation reactions that can lead to unwanted color changes and off-flavors.
1. Sous vide tenderizes tough cuts of meat and retains the flavor and moisture of any meat, fish, or poultry cooked in a vacuum pouch.
  2. Sous vide cooking time varies by the final temperature desired and the thickness of the cut of meat. For example, to cook a rare steak sous vide, a ½-inch steak takes 15 minutes, a 1-inch steak takes 90 minutes, and a 2-inch steak takes 2 hours. Steaks cooked medium would take much longer.

3. Sous vide meat and fish are usually seared for the desired browning just before serving (e.g., a blow torch or a hot skillet).
  4. Sous vide can be improvised without a hot water bath machine by using a small cooler as follows:
    - a. A small cooler should be almost full of hot water (almost boiling).
    - b. The meat or fish should be placed in a Ziploc® bag with the air removed. It is best to hang the end on the cooler edge. Then the lid must be closed.
    - c. After 30 minutes, the temperature of the water should be checked. The water should be 6°F above the desired cooking temperature. If it is not, some water should be removed and more hot water should be added. The food should be kept in the cooler of hot water until the desired food temperature is reached.
- F. **Spherification** is the shaping and encapsulation (capture) of a liquid inside spheres held by a thin gel membrane that visually resembles caviar. It is a food reengineering manufacturing process. Spherification gives liquids—juices, sauces, and soups—the appearance of caviar or small balls. It is solid on the outside with liquid on the inside. Sometimes the shapes are larger spheres called ravioli. Sodium alginate and calcium chloride create a sturdy outer membrane that contains a liquid juice (e.g., fruit, vegetable, or mushroom) because the salt extracted from the brown algae cells (the source of sodium alginate) makes the sphere flexible. The thin membrane bursts when eaten and releases a burst of flavor on the tongue. Unlike agar-agar, the gelling with sodium alginate is completed in cold conditions.
1. Basic spherification—Basic spherification is immersing a liquid containing sodium alginate in a high-calcium bath. The calcium ions migrate from the sphere’s exterior to its interior and trigger the membrane’s gelification. The process creates a wall that traps liquid inside the sphere (a process similar to gelification). A person should scoop out the mixture quick enough so it jellies on the outside and stays liquid on the inside. The result is caviar-shaped balls. Other types of spherification are reverse spherification and frozen reverse spherification.
  2. Simple spheres—Dropping water into flavored dry gelatin (Jell-O) produces simple spheres. The process works best using an eyedropper or pipette, but drops from a spoon provide irregularly shaped spheres. This is a simplistic method of making spheres using the gelification process.
  3. Large spheres—Larger spheres are produced in a silicone mold to flavor ravioli. Any flavors can be formed into ravioli using a recipe containing sodium alginate and calcium chloride. Some large spheres are frozen in the silicone molds.
    - a. Mango ravioli
    - b. Custard ravioli
    - c. Dragon fruit ravioli
- G. Other molecular gastronomy techniques
1. Powderizing is the transformation of any fatty food ingredient into a lightly flavored powder. High-fat ingredients (e.g., chocolate, peanut butter, and bacon)

- may be transformed to a fine powder by using maltodextrin. As the maltodextrin additive is blended with the food item, it forms a powder.
2. Suspensions use xanthan gum to defy gravity by suspending fruit, herbs, or flavor caviar in a liquid. The xanthan gum allows items to be “suspended” in a liquid rather than floating to the top or sinking to the bottom. The xanthan gum creates bonds that join between the gum molecules. These bonds form a network to trap air in the liquid. Many beverages are served with suspended fruits, herbs, or flavor caviar in the drink.
  3. Layering produces distinctive layers of liquids or gels in a clear glass container or silicone mold. Gelatin is used to thicken and turn liquid food into a solid gummy gel. Each layer added to the product must be less dense (lighter in weight) than the previous layer to allow it to float on top of the last layer.
  4. Smoking infuses smoke flavor into unusual foods (e.g., beer, ice cream, and spinach salad). Sometimes dry ice is used to give a smoking appearance. A molecular gastronomy tool—a smoking gun—coats the food with a surface infusion of smoke flavor. It allows the cook or chef to create a smoky flavor without overcooking or drying food. The smoking gun can be used on the surface of beverages, too.
  5. Edible paper or film is made from soybean, rice, and potato starch. It is used for transparent ravioli, transparent forms to hold morsels, and flavor-infused paper. Soy lecithin is the additive in edible film wrappers and acts as an emulsifier.

**Teaching Strategy:** Share the following video: <http://www.chefsteps.com/activities/improvised-sous-vide-insulated-cooler-method>. [NOTE: You may wish to make this video “resident on your hard drive” to prevent delays in play time.] Use VM–E through VM–K to illustrate and to facilitate a discussion.

A demonstration or class experiment could compare freshly whipped cream, stabilized whipped cream, and a powdered dessert topping mix (e.g., Dream Whip). One or two data tables could be designed to compare the three options for whipped toppings. Variables could include stability over a period of time (every hour or 24 hours). To evaluate stability, use the same volume of different toppings, and cover the same size circular pattern. Then measure the height at the beginning and at various intervals of time. Another data table could evaluate color, appearance, cost to prepare, time to prepare, and overall taste. [NOTE: Frozen whipped topping would not work well in the comparison of whipped cream mixtures, as frozen whipped topping is a totally different product than heavy cream types. You may ask students to compare the ingredients in heavy cream with that of a frozen whipped topping.]

Assign LS–A. Stabilized whipped cream or extra frozen whipped topping (from the demonstration above) could be placed on the “Gelatin 1-2-3 lab” as a garnish. The simple gelatin spheres described in the spherification category could be made and placed on top of the “Gelatin 1-2-3 lab” or sampled after the demonstration as a snack food.

**Objective 3:** Describe the chemistry and physics of MG additives, supplies, and equipment.

**Anticipated Problem:** What additives, supplies, and equipment are required to produce MG recipes?

### III. Supplies and equipment

#### A. Additives: natural texturing agents

1. **Agar-agar** is a gelling agent extracted from the cell walls of red algae and used as a food thickener. In Malay-Indonesian languages, the name agar-agar is literally “jelly.” In molecular gastronomy, this powdered gel is used to form many gel shapes: pearls, spaghetti, lentils, prisms, etc. It is a vegetarian alternative to animal gelatin.
2. Calcium salts are mineral salts. Those used in MG processes include calcium chloride, calcium lactate, and calcium gluconate. A mixture of gluconate and calcium lactate can be found under the name “calcium gluconolactate.” In MG, it is used in basic spherification and reverse-spherification processes in reaction with sodium alginate (e.g., sodium alginate needs a source of calcium to form a gel).
3. Carrageenan is a gelling agent from several species of red algae. It is a thickening and a gelling agent. The commercial food industry is the largest user of carrageenan. It is used as an anti-settling agent for light mayonnaise and light salad dressings; as a stabilizer to prevent the separation of proteins in cottage cheese and ice cream; and to keep the chocolate particles suspended in chocolate milk.
4. Gelatin is a protein food additive from collagen in meat and fish bones released by boiling. It is typically packaged as unflavored gelatin in powdered or sheet forms.
5. Gellan gum is a gelling agent made from fermented algae. In MG, gellan gum produces a variety of firm-jellied pieces with distinctive shapes. It is water-soluble and is used primarily in the food industry as an anti-settling agent, a thickener, and a stabilizer for prepared foods. Chefs use gellan gum to produce the gels for terrines and aspics.
6. Liquid nitrogen is the element nitrogen (N) in a liquefied state. It is used to cool quickly or to extract flavors with evaporation at a temperature of  $-321^{\circ}\text{F}$  ( $-196^{\circ}\text{C}$ ). It is a cryogenic (very low temperature) fluid that causes rapid freezing when it contacts living tissues. Once the food is frozen, the nitrogen “boils away” and creates a thick fog. In MG, this liquefied gas produces frozen foams and ice cream. [CAUTION: The extreme cold of liquid nitrogen makes handling dangerous. Training is required prior to use to understand reactivity and burn risk. Aprons, gloves, and other specially designed safety gear are best used when handling liquid nitrogen.]
7. Maltodextrin is an “unsweet” sugar (a polysaccharide) from corn, wheat, potato, or tapioca starch that absorbs fat flavors (e.g., bacon and chocolate)

and remains a powder. First the fatty food is liquefied. Then the maltodextrin is blended until the desired powder consistency is formed. Maltodextrin is a significant portion of powdered energy drinks and is used as filler in manufactured foods. In MG, its primary use is as an “aroma carrier.” It absorbs the flavor of the fatty food in which it is mixed (e.g., chocolate, almond, or bacon) and transfers that flavor to the MG dish.

8. Pectin is a **polysaccharide** (a long chained carbohydrate molecule) from berries and other fruits used in exact combinations of sugar and fruit acid to make jelly or jam.
9. Popping sugar is a sugar that contains carbon dioxide (CO<sub>2</sub>), so it “pops” or creates a fizzy feeling in the mouth. The “pops” are usually audible. It is small bits of melted sugar (sucrose, lactose, and glucose syrup) to which carbon dioxide is introduced. The sugar is melted and then cooled in the presence of pressurized CO<sub>2</sub> so the sugar bits trap the CO<sub>2</sub>. As a result, when a person bites into popping sugar, the sugar bits “pop.” Carbon dioxide is the same gas used in soft drinks.
10. Sodium alginate is a gelling agent made from brown algae. In MG, it is paired with calcium salts in the spherification technique (e.g., pearls and raviolis). The gelling process with sodium alginate is cold rather than the more common heated process using agar-agar.
11. Soy lecithin is an emulsifier made from soybean oil and is used to make any liquid an emulsion or foam or frozen foam. Lecithin is a lipid (fat) found in the cell membranes of all living beings. It is what allows humans and animals to maintain and repair cells. The soybean oil contains phospholipids: fat- and water-soluble (dissolve in fat and water) chemical compounds. The phospholipids make mixing oil and water—as for mayonnaise and hollandaise sauces—possible. The edible film discs used in MG cookery are produced from soy lecithin. [NOTE: Students could review several Nutrition Facts labels and count the number of food items in the lab that contain soy lecithin. It is everywhere!]
12. **Xanthan gum** is a thickening agent produced by fermentation, and its main function is to increase the viscosity (thickness) of a liquid. It is a complex polysaccharide: a natural thickener from a process that converts glucose sugar to acids or to alcohol. In MG, it is used to thicken sauces and dressings; to produce low-fat, no-ice cream milkshakes that have viscosity (are thick); and to suspend fruits and other items in liquids. In the food industry, xanthan gum stabilizes emulsions (e.g., salad dressings, mayonnaise, and hollandaise) by preventing oil separation.
13. Other additives
  - a. Emulsification additives: glycerin flakes and sucrose ester
  - b. Foams: Egg white powder, modified soy protein, etc.
  - c. Thickening products: kuzu root starch, locust bean gum, guar gum, and modified tapioca starch

## B. High-tech cuisine supplies and equipment

1. Molecular gastronomy uses high-tech equipment and chemicals to create physical and chemical transformations during cooking that make food unique. Molecular gastronomists are chefs who experiment with a variety of ingredients, tools, and techniques.
2. Supplies and equipment
  - a. Anti-griddles (a surface that cools and/or freezes foods)
  - b. Citrus sprayers
  - c. Cream whippers and soda siphons (with chargers)
    - (1) Immersion or siphon type whips are used to make foams and froths.
    - (2) An iSi gourmet whip uses pressurized nitrous oxide to instantly make whipped cream or sauces without mixing. One-time use cartridges are used to pressurize the iSi gourmet whip.
  - d. Dehydrators (remove moisture and/or dry food)
  - e. Digital scales
  - f. Edible film and sealers
  - g. Hot infusion siphon (infuses and/or adds flavor to a liquid)
  - h. Liquid nitrogen
  - i. pH indicator paper and pH meter (checks acid or base level of food products)
  - j. Plastic pipettes and high-grade plastic hypodermic syringes
    - (1) Pipettes produce small drops of liquid (caviar) used in the spherification processes.
    - (2) Syringes inject liquids into meat and enhance flavor and texture.
  - k. Silicone tubes, measuring cups, ice trays, and hemisphere molds (to shape foods)
    - l. Sous vide water bath (cooks food at a constant and specific temperature)
  - m. Spherical ice molds
  - n. Vacuum sealer (removes air from plastic bags)

**Teaching Strategy:** Many techniques can be used to help students master this objective. Use VM–L and VM–M to facilitate a discussion. View the video “iSi Gourmet Whip and Injectors” at <http://www.youtube.com/watch?v=bkoBEpSaPLk> to show how to operate and use the iSi gourmet whip.

- **Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. If a textbook is being used, questions at the ends of chapters may be included in the Review/Summary.
- **Application.** Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

- **Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

- **Answers to Sample Test:**

**Part One: Matching**

1. b
2. e
3. h
4. g
5. a
6. c
7. d
8. f

**Part Two: True/False**

1. F
2. T
3. F
4. T
5. F
6. T
7. T
8. F
9. T
10. T

**Part Three: Short Answer**

1. Answers will vary but should include three of the following:
  - a. Combining unusual flavors
  - b. Manipulating textures
  - c. Making theatrical presentations
  - d. Using chemistry lab equipment to create unexpected dishes
  - e. Manipulating food with additives
2. Answers will vary and should include any two examples and a brief description of molecular gastronomy additives in Objective 2.
3. Answers will vary but should include five examples and a brief description of the supplies and equipment in Objective 3.

# Molecular Gastronomy Techniques

## ► Part One: Matching

**Instructions:** Match the term with the correct definition.

- |                  |                         |
|------------------|-------------------------|
| a. collagen      | e. molecular gastronomy |
| b. dehydration   | f. polysaccharide       |
| c. effervescence | g. sous vide            |
| d. gelification  | h. spherification       |

- \_\_\_\_\_ 1. The process of drawing moisture out of food to preserve the food and/or to dry its surface
- \_\_\_\_\_ 2. The study and application of the physics and chemistry that take place during cooking
- \_\_\_\_\_ 3. The shaping and encapsulation (capture) of a liquid inside spheres held by a thin gel membrane that visually resembles caviar
- \_\_\_\_\_ 4. A technique that involves sealing food in an airtight plastic bag and cooking it in a water bath for several hours on low heat
- \_\_\_\_\_ 5. The structural protein in the connective tissue of animals
- \_\_\_\_\_ 6. A chemical reaction that results in the escape of gas from a body and the foaming or fizzing that results from the release of the gas
- \_\_\_\_\_ 7. The molecular change of a liquid food to a solid, gel-like food
- \_\_\_\_\_ 8. A long chained carbohydrate molecule

## ► Part Two: True/False

**Instructions:** Write *T* for true or *F* for false.

- \_\_\_\_\_ 1. Nitrogen cooking flash freezes any food it touches at 321°F.
- \_\_\_\_\_ 2. When a liquid food is cooked by submerging it into nitrogen, the outside of a liquid food will be solid while the inside stays liquefied.





# WHAT IS MOLECULAR GASTRONOMY?



**Shrimp and Lemon  
Mousse Foam**



**Boba Gel Pearls**



**Mango Gel**



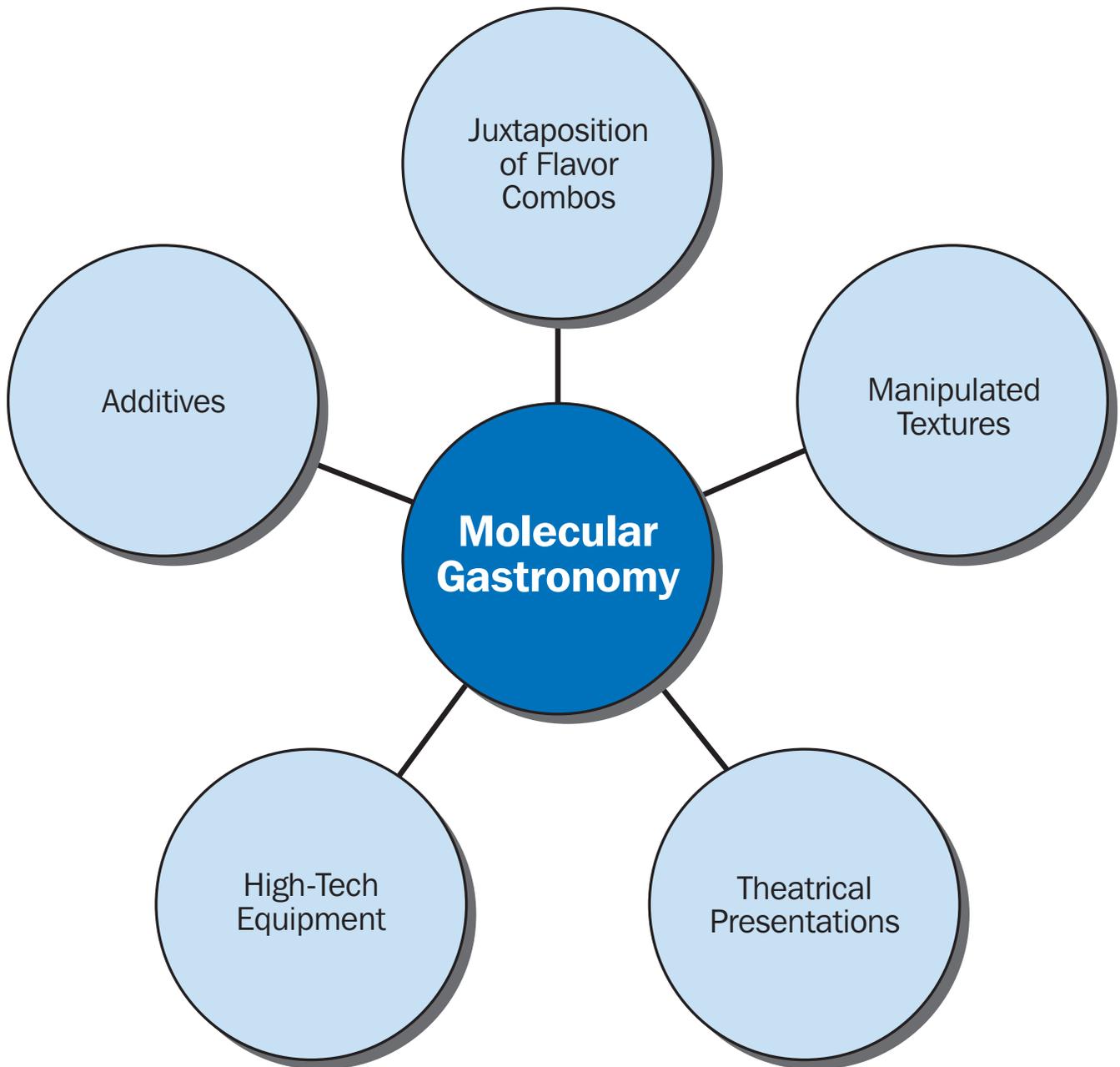
**Molecular Salad on a Spoon**

# WHAT IS MOLECULAR GASTRONOMY?

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Molecular gastronomy combines food science and culinary arts to transform ingredients into an innovative modern cuisine. In this image, MG balsamic vinegar “caviar” is presented in cherry tomatoes with an emulsion.





# HOW DO MG COLLOIDS WORK?

A colloid is a material composed of tiny particles of one substance dispersed, but not dissolved, in another substance. Which type(s) of MG colloid are represented in this “Club Soda with Lime” drink: foam, emulsion, and/or solid emulsion?



Type	The Science Description	Examples
Foam	Gas dispersed in a liquid	Whipped cream and beverage foams
Solid foam	Gas dispersed in a solid	Marshmallows
Gel	Solid dispersed in a liquid	Gelatin and jelly
Emulsion	Liquid dispersed in a liquid	Mayonnaise, milk, and cream
Solid emulsion	Liquid dispersed in a solid	Butter and cheese

Source: Molecular Gastronomy at <http://science.howstuffworks.com/innovation/edible-innovations/molecular-gastronomy2.htm>

# MG CHEFS AND RESTAURANTS

MG chefs and restaurants merging science with culinary arts include:

- ◆ Grant Achatz, Chef, *Alinea*, Chicago, IL
- ◆ Jonas Halstead, Chef, *1515 Restaurant*, Denver, CO
- ◆ Dominique Crenn, Chef, *Atelier Crenn*, San Francisco, CA
- ◆ Bruno Chemel, Chef, *Baumé*, Palo Alto, CA
- ◆ Todd Erickson, Chef, *Haven*, Miami Beach, FL
- ◆ Rob Evans, Original Chef, *Hugo's*, Portland, ME
- ◆ Michael Voltaggio, Chef, *Ink.*, Los Angeles, CA



**A molecular club soda and mint “bubble”**

# MOLECULAR GASTRONOMY TECHNIQUES

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- ◆ Dehydration
- ◆ Foam
- ◆ Fizz
- ◆ Siphon whip
- ◆ Flash freezing
- ◆ Gelification
- ◆ Sous vide
- ◆ Spherification
- ◆ Powderizing
- ◆ Layering or smoking
- ◆ Edible paper or film

# DEHYDRATION

Dehydration is the process of drawing moisture out of food to preserve the food and/or dry its surface. Molecular gastronomists use dehydration to provide crispiness and flavor to a dish: crispy sheets, dusts, and flavored powders. This dish—Foie Gras Asian Style with Green Apple and Ginger Crunch—uses dehydrated and coiled foie gras and crispy ginger crunch.



# EMULSIFICATION: FOAMS AND FROTHS

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**Coffee Caviar with Milk Foam and  
Sugar Decoration**



**Braised Beef with Potato Chips  
and Beetroot Froth**



**Raspberry Caviar with Strawberry  
Foam and Caramel**

# FLASH FREEZING OR NITROGEN FREEZING

Flash freezing or nitrogen freezing is “cooking” with liquid nitrogen that flash freezes any food it touches at  $-321^{\circ}\text{F}$  ( $-196^{\circ}\text{C}$ ). As the liquid nitrogen “boils away,” it gives off a thick nitrogen fog that adds drama to food preparation and presentation. Liquid nitrogen is transported in special flasks and is dangerous to the skin. Training to handle liquid nitrogen is required prior to use to understand reactivity and burn risk.



This Caramel Popcorn Vanilla Panna Cotta dessert has been treated with liquid nitrogen.



# GELIFICATION



**Passion Fruit and Lemon Gel Pudding in a Martini Glass with Mint Sprig**



**Fresh Strawberry with Mint Gel Spaghetti**



**Strawberry Boba Tea with Falling Red Tapioca Pearls,  
Ice, and Ripe Strawberries**

# SOUS VIDE

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**Steak in a Sous Vide Bag**



**Sous Vide Low-Temperature Water Bath**

# SPHERIFICATION

Spherification is the shaping and encapsulation (capture) of a liquid inside different-sized spheres held by a thin gel membrane that visually resembles caviar. It is a food reengineering manufacturing process: solid on the outside and liquid inside. Basic spherification is immersing a liquid containing sodium alginate in a high-calcium bath.





**Mint Caviar and Molded Ravioli Sphere**



**Raspberry Caviar on Blueberry Gel Dessert**

# GELATIN GRANULES AND GELATIN SHEETS

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**Gelatin is an animal gelling agent used to make numerous mousse, pie, and layered desserts.**



**Pectin is the gelling agent in gummy bears, gumdrops, and many jellies and jams.**

# MOLECULAR GASTRONOMY EQUIPMENT

Cooking was the first application of chemistry. All cooks and chefs practice science techniques every day. This image is a food science experiment evaluating the vitamin C content of three juices. Molecular gastronomy uses many of these same pieces of equipment.



The iSi® cream whippers use nitrous oxide to instantly make whipped cream or sauces without mixing. One-time-use cartridges are used to pressurize the MG gourmet whippers.



# Gelatin 1-2-3: A Simple Foam, Layering, and Gelification

## Molecular Gastronomy Lab

### Purpose

The purpose of this activity is to prepare a simple molecular gastronomy recipe.

### Objectives

1. Identify the molecular gastronomy (MG) techniques to be used in the lab.
2. Prepare the MG dessert.
3. Evaluate the MG food product using a data table.
4. Reflect on the way the techniques of foam, layering, and gelification altered the appearance of a simple gelatin dessert with whipped topping.

### Materials

- ◆ liquid measuring cups
- ◆ medium bowl
- ◆ mixing spoon
- ◆ teapot or pan to boil water
- ◆ blender
- ◆ spatula
- ◆ four clear glass dessert cups
- ◆ class notes
- ◆ paper
- ◆ writing utensil



## Procedure

1. Your instructor will divide the class into groups of four. Use sanitation techniques (e.g., keeping hands and equipment clean during food preparation).
2. Review your molecular gastronomy notes.
3. Read the recipe for Gelatin 1-2-3. After collecting four clear glass dessert dishes and the recipe ingredients, follow the preparation steps.

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### Gelatin 1-2-3

one 4-serving size strawberry flavored gelatin (or any flavor)

$\frac{3}{4}$  cup boiling water

ice cubes

$\frac{1}{2}$  cup cold water

$\frac{1}{2}$  cup thawed frozen whipped topping

- a. Dissolve dry gelatin mix in boiling water in bowl. Using a clear liquid measuring cup, add enough ice cubes to cold water to measure  $1\frac{1}{4}$  cups; add to gelatin mixture. Add to blender. Cover and blend 30 seconds.
  - b. Add whipped topping to gelatin mixture in blender; cover. Blend until smooth.
  - c. Pour evenly into four dessert dishes. Refrigerate a minimum of 20 minutes or until set. [NOTE: If storing overnight in the refrigerator, cover the individual dessert dishes with film (careful not to disturb the top surface of the dessert), or place them in a covered container.]
4. Design a data table to evaluate the sensory qualities of the Gelatin 1-2-3 product. A sample is shown below. Change and/or add sensory qualities as desired.
-

## Gelatin 1-2-3 Sensory Evaluation

Taste and describe each layer in detail.

Sensory Evaluation	Bottom Layer	Middle Layer	Top Layer
Aroma			
Color			
Flavor			
Consistency			
Mouth feel			
Other: _____			

5. Describe how the MG techniques of foam, layering, and gelification altered the appearance of a simple gelatin dessert with whipped topping.

a. Foam:

b. Layering:

c. Gelification:

- d. Would you obtain the same results if the whipped topping were folded into the slightly thickened gelatin? Why or why not? Describe.
6. What are other molecular gastronomy techniques that might be used with flavored gelatin? Describe the technique in the space provided.
7. Turn in your completed lab sheet and evaluation to your instructor.

# **Gelatin 1-2-3: A Simple Foam, Layering, and Gelification Molecular Gastronomy Lab**

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1. Plan to use the recipe prior to student use to ensure that the foaming, layering, and gelification process produces the desired three layers.
2. Optional: The following options require no MG-specific equipment and would use typical food lab equipment and tools. Assign groups to other MG recipes (rather than all completing the same Gelatin 1-2-3 dessert task). The same sensory evaluation format may be used for the following recipes, and you may need to add an additional category for the Boba and Bubble Tea (gelification) and the sous vide (texture) recipes.
  - a. Boba and Bubble Tea Recipe (tapioca caviar)  
<http://www.thekitchn.com/how-to-make-boba-and-bubble-tea-98067>
  - b. Gumdrop Recipe (pectin)  
<http://www.instructables.com/id/Grape-Gumdrops/>
  - c. Gummy Bear Recipe (pectin)  
[http://www.ehow.com/how\\_6947506\\_make-gummy-bear-steps.html](http://www.ehow.com/how_6947506_make-gummy-bear-steps.html)
  - d. Jellies Candy Recipe (pectin)  
<http://honestcooking.com/homemade-candy-pectin-jellies-recipe/>
  - e. Improvised Sous Vide—Insulated Cooler Method  
[NOTE: This sous vide recipe requires a thermometer, an ice chest, zipper plastic bags, and a short stovetop searing time at the end of the sous vide process.]  
<http://www.chefsteps.com/activities/improvised-sous-vide-insulated-cooler-method>