Monell Chemical Senses Center
2022 Hybrid Spring Colloquium

April 4, 2022

Unpleasant Chemosensation: The Science of Yucky Flavor

April 5, 2022

Somatosensation: The Science of Mouthfeel

Note: As part of our meeting green goals this book is completely virtual and links to other resources typically available at the Spring Colloquium.

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SCHEDULE OF EVENTS

Monday April 4th

“*Unpleasant Chemosensation: The Science of Yucky Flavor*" Chair: Paul Wise		
12:30 pm	Coffee Welcome Session	
1:00 pm	Intro	P. Wise
1:30 pm	How Could Good Taste be Bad?	P. Breslin
2:00 pm	What Makes a Smell Bad	P. Dalton
2:30 pm	**Coffee Break**	
2:45 pm	Appetitive and Aversive Responses to Food Textures: A Sensorimotor Outlook	R. Pellegrino
3:15 pm	Getting to Like Unpleasant Things with a Focus on Oral Irritation and Disgust-Related Odors	P. Rozin*
3:45 pm	The Bad Taste of Medicine: It's Personal!	J. Mennella
4:15 pm	Bitters, not Bitter - Evidence for Qualitatively Distinct Percepts in Humans	J. Hayes*

Tuesday April 5th

"Somatosensation: The Science of Mouthfeel" Chair: Linda Flammer		
7:30 am	Coffee Welcome Session	
8:00 am	Somatosensation: The Science of Mouthfeel	L. Flammer
8:30 am	Mechanosensory Cells and Neurons that Underlie Flavor Perception	Y. Moayedi*
9:00 am	Getting “in touch” with Oral Texture Perception: The Bottom-Up Approach for Assessing How Humans Perceive Texture within the Oral Cavity	B. Miles*
9:30 am	**Break**	
9:45 am	Oral Tribology – Science Behind Sticky to Slippery and Beyond	A. Sarkar*

10:15 am	How Do We Measure an Experience that is Constantly Changing?	L. Flammer
10:45 am	Integration of Diverse Orosensory Inputs Generates the World of Mouthfeel Perception	P. Breslin
11:15 am	**Panel Discussion and Research Hypothesis Generation** Panelists: P. Breslin, M. Cheung, L. Jegede*, B. Miles*, Y. Moayedi*, N. Rawson, A. Sarkar*, P. Wise,	Moderator: L. Flammer
11:55 am	Closing Remarks	N. Rawson
1:00 pm	**Panel Discussion "How Innovation is Impacting the Field of Malodor Detection and Masking"** Panelists: Fanny Turlure (Aryballe), Evan Beach (Aryballe), Christopher Maute (Monell)	Presented by Aryballe

***Guest Speakers**

John E. Hayes, Ph.D.
Professor, Food Science
Director, Sensory Evaluation Center
The Pennsylvania State University

Brittany Miles, Ph.D.
Post-Doctoral Researcher
The Ohio State University College of Food Agricultural and Environmental Sciences

Yalda Moayedi-Esfahani, Ph.D.
Assistant Professor in the Departments of Neurology and Otolaryngology–Head & Neck Surgery at Columbia University

Paul Rozin, Ph.D.
Professor, Psychology
University of Pennsylvania

Anwesha Sarkar, Ph.D.
Chair of Colloids and Surfaces, School of Food Science & Nutrition
University of Leeds

Presentation Abstracts

Introduction

Paul Wise

Hedonic response is perhaps the most salient aspect of flavor and other chemosensory experience. Based on hedonic response we approach or avoid, consume or reject. But what makes some sensations desirable and others undesirable? Sweetness, which usually indicates a rich source of energy, tends to be innately pleasurable, whereas bitterness, which may indicate the presence of toxins, tends to be innately aversive. Hedonic response to these tastes is sometimes described as "hardwired," but as Dr. Breslin will discuss, hedonic response can depend on past experience, context, and expectations. For example, many people not only tolerate but learn to savor bitterness in chocolate, coffee, or beer. Similarly, chemical irritation can warn us of exposure to potentially harmful levels of chemicals, and tends to be aversive by default. Yet, as Dr. Rozin will discuss, many people learn to love the burn of hot peppers or similar sensations in the context of foods. Dr. Rozin hypothesizes that learning to love hot peppers may be but one example of "benign masochism" or enjoyment of sensations and emotions associated with potential harm, after we learn that we are actually safe in a given context. As Dr. Dalton will discuss, hedonic response to smell is perhaps the most dependent on learning, experience, and expectations of all chemosensory perception. Mouthfeel and texture are also important for hedonic response and play a role in determining differences among consumers in responses to foods, as Dr. Pellegrino will discuss. Dr. Hayes will discuss some recent work suggesting that different compounds described as bitter may actually give rise to different experiences, with bitterness perceived as stronger or weaker in different parts of the mouth or at different times during sipping and swallowing. Thus, we may come to expect certain spatial and temporal patterns of bitterness in particular foods and beverages, such that bitter compounds in hops taste right in beer, but other bitter compounds might not. Of course, bitterness might be expected in a given context but still be problematic, such as the strong bitterness of many medications children must take orally. Dr. Mennella will discuss some work on individual differences in responses to bitterness in children and implications for acceptance of medicines.

References

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How Could Good Taste be Bad?

Paul Breslin

When it comes to dis-tasteful experiences, foods and beverages may be perceived as unpleasant, though they contain typically-enjoyed stimuli. Reciprocally, typically-disliked tastes can also be enjoyed. Such inversions are common; just as many enjoy the bitterness of dark chocolate, espresso, and olives, so too, many dislike stimuli such as sugar, salt and fat depending on circumstances. What are these circumstances? I offer here five types of occasions when otherwise pleasant stimuli are rejected as unpleasant:

1) Preference-Aversion: Past the Bliss point of a preference-aversion function, sugar is too syrupy, fat is too greasy, salt is overly salty.

2) Mismatched Signal and Reward: Diet beverages are rejected relative to sugared beverages, even though the diet beverages are sweet. Sweetness without calories is a mismatch of an expected ratio of the two.

3) Unexpected Identity: A great tasting tomato juice may be rejected if presented as blood-orange juice. The match to memory engram is a poor fit to the expected flavor of orange juice.

4) Negative Consequences. Learned taste aversion from associated nausea. Conditioned taste aversion (CTA) causes the dislike of virtually any pleasant food or beverage.

5) Identity of Edible as Either Food vs. Beverage: Many foods are not acceptable as beverages and vice versa. People may eat a lot of maple syrup when on pancakes, but will not drink it from a glass; they may eat a steak with a fork and knife, but not drink it when pureed; they may eat hot savory water from a bowl, but will not drink savory water in a glass.

The influence of stimulus intensity, contextual cues, learning, expectation, and perceived forms can determine whether a taste or flavor is unpleasant and may even influence market success of products, despite the inclusion of traditionally pleasant stimuli.

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What Makes a Smell Bad

Pamela Dalton

What properties make an odor smell good? What makes an odor smell bad? Are we hard-wired to be attracted or repelled by any odors? Our noses are exquisitely sensitive chemical detectors, yet in the absence of context and experience, our olfactory system alone cannot parse the pleasantness or the safety of the airborne chemical molecules that surround us. Infants and very young children often express few negative evaluations of their odor world. Yet soon, they begin to adopt the hedonic responses of elders in their culture. In this talk, I will review the role of experience and context in the development of our hedonic responses to odor, emphasizing the malleability of our olfactory experience, which can shift on a momentary basis.

References

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Appetitive and Aversive Responses to Food Textures: A Sensorimotor Outlook

Robert Pellegrino

The sense of touch helps the consumer determine nutritional value and possible hazards that lead to changes in oral behavior. Texture is a material property that arises from the combination of structural, mechanical, and surface properties of foods which are detected through the senses of vision, hearing, and touch. Specific to oral textures, a feedback loop of sensory and motor actions move the jaw and tongue, along with lubrication from saliva, to manipulate the texture of the food to make it safe for ingestion. Texture is integral to the eating process leading to a food being accepted or rejected. Texture terms designed to relate fundamental, measurable properties with perceptual experience may be simple (e.g. soft) or complex (e.g. juicy), and different textures may arise as the food is broken down by eating processes. Additionally, physiological to psychological differences in individuals create variation in liking or disliking some textures depending on the food.

In this presentation, I will give an overview of how the texture-involved senses drive motor behaviors related to consumption or lack of (e.g. chewing parameters and gagging). I will discuss different textures that arise during mastication, impacting consumer's acceptance or rejection of a food, as well as segmentation of texture liking within populations.

References

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Getting to Like Unpleasant Things with a Focus on Oral Irritation and Disgust-Related Odors

Paul Rozin

Humans, and only humans, acquire likings for initially unpleasant things. Most of these have clearly sensory signatures. I have called this phenomenon benign masochism. I initially came to this view from studying how billions of humans come to love the sensation of oral irritation produced by chili pepper. The sensation is innately negative, but this same sensory representation becomes positively valenced after some experiences with it. The same is true for the sensory, decay odors, that are associated with disgust. Unlike oral irritation, these odors are not innately negative, but become negative in early development. A subset of these odors, depending on context, become attractive. An example is attraction by some to the odor of stinky cheese (decayed milk) or Southeast Asian fish sauce (decayed fish). There are abundant other examples like these, including acquired likes for extreme temperature sensations on the skin or in the mouth, the muscle pain associated with some types of exhaustion, fear as in roller coasters, and, most puzzling and non sensory, sadness as in films or music. Benign masochism is the hypothesis that all these things arise from the human realization that apparently harmful things are actually harmless, a matter of mind over body.

References

Rozin, P. (1990). Getting to like the burn of chili pepper: Biological, psychological and cultural perspectives. In B. G. Green, J. R. Mason & M. R. Kare (Eds.), *Chemical senses, Volume 2: Irritation* (pp. 231-269). New York: Marcel Dekker.

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The Bad Taste of Medicines: It's Personal!

Julie A. Mennella

Most of the world's children at some point require medicine. Some will refuse to take it because of its yucky taste, which can lead to substantial worsening of disease, increased health care costs, and even death. Although adults have an advantage because they typically take their medicines in solid oral dosage forms, which encapsulates the taste of bad taste of the active pharmaceutical ingredients, children vary greatly in their ability to swallow tablets and capsules and often take their medicines in liquid form which often tastes more bitter and/or irritating in the mouth. During the past few decades, we have made progress in developing methods to study taste in pediatric populations. In this talk, we will highlight basic research findings on bitter taste in children and the use of adult sensory panelists to investigate individual differences in the taste of a variety of pediatric formulations. Factors inherent to both the individual and the medicine contribute to challenges in medication acceptance. Such personal variation – a hallmark of human perception – is the focus of our research program, which takes into account individual differences in people's genes, taste and flavor perception, because "nobody is average".

References

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Bitters, not Bitter – Evidence for Qualitatively Distinct Percepts in Humans

John E. Hayes

Diverse chemical classes activate a broad range of TAS2R receptors and are described as bitter by humans. Sensations from these chemicals are innately aversive, and stereotypical aversive responses are conserved across species, possibly as a warning against toxin ingestion. Critically however, stimuli may share a common verbal description in English without implying the specific sensations they evoke are qualitatively identical; for example, capsaicin and allyl isothiocyanate (from chilies and wasabi, respectively) are both described as 'burning', yet they are clearly perceptually distinct. Likewise, a growing body of data from different complementary psychophysical methods indicates humans can perceive perceptual differences between bitter stimuli. In Project 1, we determined isointense concentrations for 11 food grade bitter stimuli (at the group level) and confirmed none had any meaningful tastes or sensations besides bitter. These stimuli were then given to volunteers in a directed free sorting task; using Perceptual Mapping and Cluster Analysis, we found evidence of 3 distinct clusters, suggesting individuals may perceive these compounds differently, despite intensity matching (McDowell, unpublished). In Project 2, we compared intensity of quinine, sucrose octa-acetate, and tetralone on different regions of the oral cavity using whole mouth sip and spit delivery and localized application with cotton swabs. With sip and spit delivery, the stimuli were matched for intensity on the roof of the mouth and the middle and posterior tongue, but tetralone bitterness was depressed on the anterior tongue. When applied to discrete tongue regions, quinine was more intense than tetralone on fungiform papillae, but the reverse was true on circumvallate papillae (Higgins & Hayes 2019). In Project 3, we generated time intensity profiles for 10 isointense bitter stimuli. When standard scaffolding parameters (Tmax, AUC, etc) were compared via Principal Component Analysis and Cluster Analysis, we found evidence for 2 distinct clusters: the first typified by faster in-mouth onset, and faster rate of decay, and a second group with slower onset rate, slower decay, and a post swallow increase in intensity (Higgins, Gipple, & Hayes 2021). In Project 4, we intensity matched 3 bitterants (quinine, sucrose octa-acetate, and isolone) in a non-hoppy non-alcoholic beer matrix. These were used in a Difference-From-Control (DFC) task with the isolone spiked sample as the control. Both quinine and sucrose octa-acetate spiked beers were significantly different from a blinded control (Higgins & Hayes 2020). Collectively, these data suggest humans are able to perceive subtle differences between various bitter stimuli in aqueous solutions and real foods, even when they are not able to describe the differences verbally, and that these perceptual differences may be cued by temporal and regional differences.

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Somatosensation: The Science of Mouthfeel

Linda Flammer

Our understanding of taste, smell, and irritation has come a long way. Yet our knowledge of oral somatosensation, specifically mouthfeel, is much less understood. This colloquium will provide you with a solid scientific overview of what is known about mouthfeel from several different disciplines. First, we will review terminology. There are many senses that comprise the oral experience of foods, beverages, and personal care products besides taste and smell. What exactly is somatosensation and is it different from mechanosensation or chemesthesis? What is proprioception? Does it play a role in mouthfeel? Are all of these senses discrete or is there overlap? After clarifying the scientific terminology, each of our speakers will provide you with the latest developments in the science of mouthfeel. Dr. Moayedi will guide us through the cells and neurons in the mouth that give rise to mechanosensation. Dr. Miles will link individual perception with physical structures in the mouth to understand why individuals may vary in their ability to perceive texture attributes and why certain individuals may be more or less sensitive to given percepts. Dr. Sarkar will give us a primer on oral tribology. She will explain how the perception of mouthfeel is dynamic and the result of friction or lubrication created between the surfaces of the mouth including the tongue, the hard and soft palates, and the teeth. Next, I will return to highlight the need for our sensory methods to evolve to capture the dynamic nature of mouthfeel and propose a new approach. We will also visit the dizzying array of terms used to describe mouthfeel and then underscore the need to move toward well-defined, quantifiable, and standardized sensory attributes so that we can clarify this complex sense. Next, Dr. Breslin will consider how taste, smell, and somatosensation are integrated to create the overall oral experience of food, beverages, and personal products. Finally, we will have a panel discussion to identify pressing research questions and hypotheses. The goal of the discussion is to outline a compelling research program on mouthfeel that will enable the development of healthier and more sustainable products such as plant-based meat alternatives and low-alcohol adult beverages with acceptable mouthfeel, and new foods tailored for the needs of an aging population.

References

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Mechanosensory Cells and Neurons that Underlie Flavor Perception

Yalda Moayedi Esfahani

Oral mechanosensation subserves a myriad of functions in feeding including flavor perception, bolus preparation, and swallow. During feeding, food contacts oral and upper airway sites, initiating mechanotransduction. Each site has a unique complement and organization of mechanosensory cells and neurons embedded in its mucosa that transduce features of food texture and contribute to flavor construction and feeding mechanics. These tissues also have unique structural and biomechanical properties that influence the responses of mechanosensory neurons to touch. Understanding the diversity of mechanosensory organs in oral tissues, their environment, and their response properties allows us to build hypotheses about how they contribute to flavor construction. Recent work describes the diversity of oral mechanoreceptors and their response features. The organization of mechanoreceptors in the hard palate is homologous to that of the fingertips with Merkel-cell neurite complexes at the base of epithelial pegs and Meissner's corpuscles between pegs. This arrangement confers the palate with high tactile acuity that gives it the ability to detect moving and static stimuli. The tongue, on the other hand, has unique end organs whose functional properties are not well known. We investigated the functional properties of trigeminal mechanoreceptors innervating the tongue and found five distinct functional groups, each with varying response thresholds and kinetics. Collectively, the proportion of mechanosensory units suggests that the tongue is best equipped for sensing moving stimuli, like that felt when actively feeding, drinking or speaking. We use this information to develop hypotheses on the roles of mechanoreceptors in detecting textural features of foods, like viscosity, mouthcoating, lubrication, and astringency.

References

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Getting “in touch” with Oral Texture Perception:

The Bottom-Up Approach for Assessing How Humans Perceive Texture within the Oral Cavity

Brittany Miles

Product texture and perceived mouthfeel are critical to the acceptance and liking of many products. However, studies completed trying to characterize this perception often approach tactile acuity from a “top-down” perspective, trying to understand how variations in food products or systems may result in changes in perception or liking. Insights gained from these studies have limited generalizability outside of the system of interest as they do not identify the mechanisms involved in perception, simply the effects of the changes in the system in question. An alternative to this method is the “bottom-up” approach, wherein knowledge about physical structures and their innervation is integrated with psychophysical data to understand not only how individuals may vary in their ability to perceive texture attributes, but also why certain individuals may be more or less sensitive to given percepts. To demonstrate the efficacy of this methodology, we will explore the elucidation of a perception mechanism for high-viscosity solutions ($\eta \leq 1000$cP) in the mouth. By pairing psychophysical data with anatomical characterization, we substantiate the contribution of filiform papillae and palatal rugae to viscosity perception. Average papillary length and density significantly predicted discrimination acuity on the tongue. While on the hard palate, perception ability was linked to palatal rugal attributes of compressibility and proportion of the total palate area. Moreover, sensitivity of the tongue and palate within a given individual were not correlated, suggesting that individuals may compensate for a lack of sensitivity of one tissue with sensitivity of the other. Using this “bottom-up” method of perception characterization, we pave the way for more targeted texture.

References

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Oral Tribology – Science Behind Sticky to Slippery and Beyond

Anwesha Sarkar

Oral tribology at multiple length scales[1-3] is emerging as a new paradigm in food science to quantify friction and lubrication of food-saliva mixtures in the oral surfaces. This is largely due to the current consensus on oral processing dynamics, where researchers have proposed that the well-established 'rheology' (bulk property) cannot explain all the mouthfeel features such as astringency, smoothness, pastiness *etc.*, and these perception are better explained by rather under-researched 'tribology' (surface property of food-saliva bolus based lubricants)[1,2,4]. Although biopolymers in general have attracted significant research attention for tribological analysis, systematic tribological characterization of proteins is fairly limited in literature to date. In this talk I will discuss some recent case studies from our laboratory on macroscale tribological performance of a range of plant and dairy proteins[5,6], microgels and some real food applications[7]. I will also give some examples where oral tribology has been successful in correlating friction coefficients to sensory attributes in model foods[8,9] and lubricity is used as a modifiable factor in food to trigger satiety[10,11]. Finally, development of novel 3D soft tribo-surfaces[12] to emulate the highly sophisticated real tongue surfaces in terms of deformability, roughness (height and spatial distribution of papillae) and wettability as well as tribological performance will be covered.

References

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Acknowledgements

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How Do We Measure an Experience that is Constantly Changing?

Linda Flammer

Enter "mouthfeel" into Google and a dizzying array of terms pops up. Review the literature and it becomes obvious that the terms for mouthfeel are often ambiguous and not standardized. Mouthfeel is the next sensory frontier and it is complex. To clarify this sense, it is essential to develop an agreed-upon classification model that includes well-defined, quantifiable sensory attributes with corresponding physical stimuli. In addition, the classification model must capture the dynamic nature of mouthfeel when consuming a food or beverage. For example, a potato chip is crispy when first placed in the mouth, mushy when ready to swallow, and generates an oily mouth coating which might become more salient after swallowing. Capturing multidimensional and dynamic sensory information when consuming a food or beverage remains a challenge. Descriptive analysis (DA) provides detailed profile information, but with limited ability to capture the temporal changes in perception. Temporal dominance of sensation (TDS) and time intensity (TI) methods, provide temporal change information for dominant sensations, but are limited in the number of attributes that can be measured. We need an approach that can simultaneously characterize the detailed sensory experience while taking into account dynamic changes during chewing, sipping, and swallowing. We propose a new method, Temporal Descriptive Profiling (TDP). The method divides the oral experience into three phases: 1) first 2-4 bites; 2) chewing until the point of first swallow; and 3) swallowing and mouth clearing. This method enables capturing a rich array of qualities (5-7) at each phase and characterizes the temporal changes of the oral experience. We found this method was able to better discriminate five products than DA or TDS alone.

References

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Integration of Diverse Orosensory Inputs Generates the World of Mouthfeel Perception

Paul Breslin

Mouthfeel refers to the everyday mechanical sensations from foods and beverages in the mouth that may be described as: thick, fatty, smooth, chalky, pulpy, creamy, greasy, astringent, gritty, mouthcoating, mushy, crunchy, gooey, melty, chewy, sticky, slimy, etc. These experiences arise from both the static and dynamic sensory inputs of the mechanosensory (epithelial: touch/tactile/flow) and the propriosensory (joint, muscle, ligament: tension/contraction/position/movement) components of the somatosensory modality. These sub-modality systems give rise to sensations that can be organized along several physical dimensions of: lubrication/tribology, particle size, viscosity, adhesion, elasticity, and others. There are other somatosensory sub-modalities that can modulate mouthfeel experience, such as the thermosensory system (epithelial, dental: cold/cool/warm/hot) and the nociceptive system (epithelial, dental: tissue/dental damage, irritation, burning, chemical stimulation [chemesthesis]). Furthermore, the remaining sensory modalities, taste, smell, sight, and sound, can all modulate the overall mouthfeel experience. But in the absence of mechanosensory and proprioceptive inputs, there is no mouthfeel. Some mouthfeel experiences are inherently due to the interaction of multiple physical dimensions co-occurring in the mouth. For example, creaminess involves the intersection of moderate levels of viscosity, elasticity, and lubrication. There is broad interest in understanding how oral mechanosensory experiences can be modulated by tastes and odors. For example, the addition of salt (NaCl) increases perceived fullness of a split-pea soup. In addition, the fattiness of an oral food is enhanced by the presence of dairy fat (butter) odors. We will consider how the various aspects, attributes, sub-modalities and dimensions of oral experience integrate to give rise to the holistic experience or Gestalt that we experience as mouthfeel.

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Glossary of Terms

<u>Sensory Systems of the Mouth</u>	
Chemesthesis	Chemesthesis is the chemical sensitivity of the skin and mucous membranes. Chemesthetic sensations arise when chemical compounds activate receptors associated with other senses that mediate pain and thermal perception. Examples include the burn of chili pepper, the cooling of menthol, and the tingle of carbonation.
Facial Nerve	The seventh cranial nerve performs motor and sensory functions. The facial nerve controls the muscles that help you smile, frown, wrinkle your nose, and raise your eyebrows and forehead. It also carries taste sensation and other sensory information from the anterior two-thirds of the tongue.
Glossopharyngeal Nerve	The ninth cranial nerve performs motor and sensory functions including providing taste sensation from the posterior one-third of the tongue. It also innervates the muscle responsible for elevating the larynx and pharynx during speaking and swallowing.
Mechanosensation/ Mechanosensory	Mechanosensation is the transduction of mechanical stimuli into neural signals. Mechanosensation provides the basis for the senses of touch, pressure, vibration, proprioception, pain, and hearing.
Nociception/Nociceptive	Nociception is the detection of painful stimuli. Specialized neurons detect extremes of heat, cold, mechanical, and chemical signals and alert the body of potential dangers.
Proprioception/Propriosensory	Proprioception, otherwise known as kinesthesia, is your body or mouth's ability to sense movement and location.
Somatosensation/Somatosensory	Somatosensation is the group of sensory modalities that are associated with touch, pressure, pain, temperature, position, movement, vibration, and internal body senses like a stomach ache.
Thermosensation	Thermosensation is the sensing of temperature.
Trigeminal System	The trigeminal system consists of neurons and their axons in the trigeminal nerve (cranial nerve V). It is named trigeminal because it has three branches: the eye, nose, and mouth. These neurons and their associated endings are typically activated by chemicals classified as irritants, such as air pollutants (e.g., sulfur dioxide), ammonia, ethanol, vinegar, menthol (cooling), capsaicin (burning of chili peppers), mustard, wasabi, and the like.
Vagus Nerve	The tenth cranial nerve performs important roles in involuntarymotor and sensory including mucus and saliva production, skin and muscle sensations, speech, and taste.

Cells, Neurons, Structures of the Mouth	
End Organ	The structure at the end of a peripheral nerve. Examples of end organs are the muscle end plate at the end of a motor neuron and the receptor at the end of a sensory neuron.
Epithelium/Epithelial	The thin tissue forming the outer layer of a body's surface and lining the alimentary canal and other hollow structures. Its function is to act as a covering or lining of various bodily surfaces and cavities.
Epithelial Pegs	Extensions in the epithelium that project into the underlying connective tissue in both skin and mucous membranes.
Filiform Papillae/ Papillary	Fine, small, cone-shaped papillae covering most of the back of the tongue. They are responsible for giving the tongue its texture and are responsible for the sensation of touch.
Fungiform Papillae	Raised mushroom-shaped structures that are scattered across the tongue's surface. Their number ranges between 200 and 400. They contain the taste buds and also sense temperature and touch.
Hard Palate	The roof of the mouth is the palate. The front part that is bony or hard is the hard palate.
Krause End Bulbs	A specialized sensory nerve ending enclosed in a capsule in the skin. It is associated with temperature sensations and may also be a mechanoreceptor.
Meissner Corpuscles	A cutaneous nerve ending responsible for transmitting the sensations of light touch and vibration. On the skin, meissner corpuscles are most sensitive to low-frequency vibrations between 10 to 50 Hertz and can respond to skin indentations of less than 10 micrometers. They are abundant in the fingertips and eyelids, and are also in the mouth.
Merkel Cell Neurite Complexes	A unique sensory unit that mediates mechanosensation.
Palatal Rugae	Asymmetrical and irregular elevations on the roof of the mouth, just behind the teeth. They are prominent and each individual's rugar are unique like fingerprints and can be used for identification.
Soft Palate	The roof of the mouth is the palate. The back part this is not bony but soft is the soft palate.
Transient Receptor Potential (TRP)	TRP channels are ion channels that maintain intracellular calcium homeostasis to regulate various functions in the respective cells such as pain or taste.
Methods	
Descriptive Analysis (DA)	Descriptive analysis is a method which involves the training of panellists to quantify specific sensory attributes for appearance, flavour, texture and aftertaste.
Psychophysics	A method that quantitatively investigates the relationship between physical stimuli (such as different concentrations of sucrose solutions) and the sensations and perceptions they produce (such as sweetness intensity).

Temporal Dominance of Sensation (TDS)	A sensory method to evaluate the most dominant sensation over time (Pineau, Cordelle & Schlich, 2003). Panellists are presented with a list of attributes and asked to choose the dominant ones over consumption of the product. A dominant attribute is the most striking perception at a time, not necessarily the most intense one (Pineau et al., 2009).
Time Intensity	A special form of intensity scaling that is either repeated at short intervals or continuous. It offers some advantages over a single intensity estimate, giving more detailed information on changes in flavor and texture over time.
Visual Analog Scale (VAS)	A horizontal line with verbal descriptors (word anchors) at each end to express the extremes of a sensation. Subjects put a mark on the line to indicate the degree of the sensation they are experiencing.
Physics	
Biomechanical	Biomechanics is a branch of biophysics. It focuses on how mechanical forces act on the body and how the body tissues and structures respond to these forces.
Deformability	The degree to which applying a force can make a particle or solid change shape.
Feeding Mechanics	The forces and motions used during eating such as bite force, degree of mouth opening, etc.
Friction	The resistance that one surface or object encounters when moving over another.
Kinetics	In physics, the study of forces acting on mechanisms. In chemistry and biochemistry, the study of the rates of reactions.
Lubrication/Lubricity	The control of friction and wear by the introduction of a friction-reducing film between moving surfaces in contact. The lubricant used can be a fluid, solid, plastic substance, and the like.
Oral Tribology	The science of understanding the friction and lubrication between food and beverages with saliva-coated oral surfaces including the tongue, palate, teeth, and oral mucosa.
Rheology	The scientific field that encompasses the flow phenomena of matter (solids, liquids, and gases) and notably involves time-dependent behavior under the influence of stresses.
Temporal	Relating to time
Tribology	The science of friction, lubrication and wear in interacting surfaces in relative motion
Viscosity	The state of being thick, sticky, and semifluid in consistency, due to internal friction.
Wettability	The attraction of a liquid phase to solid surface, and it is typically quantified using a contact angle with the solid phase.

Miscellaneous	
Bolus	A small rounded mass of chewed food formed in the mouth right before swallowing.
Gestalt	Gestalt psychology is a school of thought that suggests that we do not simply focus on every small component but instead, we perceive objects as elements of more complex systems. The classic phrase is "The whole is greater than the sum of its parts."
Innervation	To be supplied with nerves.
Orosensory	Relating to oral senses
Percept	An object of perception; something that is perceived.
Tactile Acuity	The extent to which one can discern small structural details in objects that touch the skin.
Transduction	Signal transduction is any process by which a biological cell converts one kind of signal or stimulus into another. For example olfactory transduction is when olfactory sensory neurons in the epithelium detect odor molecules dissolved in the mucus and transmit information about the odor to the brain.

RESEARCH INTERESTS OF SCIENTIFIC STAFF

The following lists the current research interests of the staff of the Monell Center. Click their name to go to the scientist research page on our website. These pages include information on their education, research summary, and relevant publications.

Director & President

Robert F. Margolskee

MD; Ph.D., Molecular Biology & Genetics; Johns Hopkins School of Medicine (USA)

Dr. Margolskee's long-standing research focus is on the molecular mechanisms of taste transduction, utilizing molecular biology, biochemistry, structural biology, electrophysiology and transgenesis to study the mechanisms of signal transduction in mammalian taste cells. More recently he has been studying the chemosensory functions of taste signaling proteins in gut and pancreatic endocrine cells. Other projects in the Margolskee lab focus on taste stem cells and endocrine properties of taste cells.

Distinguished Member

Gary K. Beauchamp

Ph.D., Biopsychology; The University of Chicago (USA)

My research interests include: 1) genetics of taste perception; 2) development of human chemosensory perception and preference; 3) genetics and behavior of individual olfactory identity; 4) odors as diagnostic tools; and 5) adult human flavor perception.

Members

Paul A. S. Breslin

Ph.D., Experimental Psychology; University of Pennsylvania (USA)

I am interested in human oral perception and its genetic basis. The primary focus of my work is on taste perception with an emphasis on taste discrimination, taste enhancement and suppression, and taste localization. I also study oral irritation/chemesthesis, mouthfeel, and astringency. The interactions among gustation, chemesthesis, and olfaction that comprise flavor are the topic of an ongoing research program that includes fMRI as a tool to understand regional brain involvement. In addition to human research, I conduct parallel genetic studies of the chemical senses in my Fly Lab, which uses Drosophila melanogaster as a model.

Pamela Dalton

Ph.D., Experimental Psychology; New York University; M.P.H., Drexel University (USA)

My research attempts to broadly understand how cognitive and emotional processes modify the way we perceive odor and sensory irritation from volatile chemicals. One approach involves examining the associations and disassociations between subjective (self-report) and objective markers of irritation (e.g., ocular inflammation, nasal blood flow, respiratory patterns) resulting from chemical exposure. Another line of investigation examines the relationship between exposure frequency, adaptation and clinical sequelae from exposure to airborne chemicals, both in the laboratory and in occupational and community settings. In a related effort, modeling how odorant transport factors (e.g., physico-chemical characteristics of the odorant, nasal airflow, inflammatory changes) affect these processes can provide additional insight into variation in olfactory perception among the population.

Bruce A. Kimball

Ph.D., Ecology; Colorado State University (USA)

I am a chemical ecologist with the USDA National Wildlife Research Center (NWRC). My research at Monell focuses on wildlife behavior and the chemical signals that identify friend, foe, and food. The goals of my research are increased understanding of wildlife behavior and development of practical tools to minimize wildlife damage to agricultural resources. Current research topics include: 1) phytochemical basis of herbivore foraging behavior; 2) olfactory signals associated with animal disease states; 3) cues associated with novelty or conditioned aversions; 4) mechanisms of herbivore repellents; 5) attractants for wildlife baiting systems.

Joel D. Mainland

Ph.D., Neuroscience; University of California, Berkeley (USA)

A fundamental problem in neuroscience is mapping the physical properties of a stimulus to perceptual characteristics. In vision, wavelength translates into color; in audition, frequency translates into pitch. By contrast, the mapping from chemical structure to olfactory percept is unknown. In other words, there is not a scientist or perfumer in the world who can view a novel molecular structure and predict how it will smell. My research goal is to develop a predictive model relating molecular structure and olfactory perception using a combined psychophysical and molecular approach.

Julie A. Mennella
Ph.D., Biopsychology; The University of Chicago (USA)

Dr. Mennella's research program focuses on the role of early experiences on food and flavor preferences and growth and the effects of alcohol and tobacco on women's health and infant development. Current research studies focus on the following areas: 1) how maternal diet alters the aromatic profiles of amniotic fluid and mother's milk and how such early flavor experiences affect food preferences during weaning and childhood; 2) elucidation of sensitive periods in flavor learning and developing evidence-based strategies to promote acceptance of fruits and vegetables among children; 3) determine the behavioral and physiologic mechanisms by which diet composition affects energy balance and growth in infants studying the pharmacokinetics and pharmacodynamics of alcohol in women; 4) determine effects of age and genotype on taste sensitivity and preference across the lifespan; 5) determine efficacy of strategies of reducing bitter taste in children and impact taste has on medication compliance and acceptance; and 6) effects of alcohol and tobacco use during lactation on various aspects of women's health, lactational performance and mother-child interaction. In addition to her research, she founded and then directed a program at Monell Center from 1991-2007 that encouraged under-represented minority high school and undergraduate students to pursue careers in science and medicine. Dr. Mennella has held a number of leadership positions in professional scientific societies and working groups at the National Institutes of Health and other international scientific and health organizations. She is the recipient of several grants from the National Institute of Deafness and Other Communication Disorders and the Eunice Kennedy Shriver National Institute of Child Health and Human Development; the author or co-author of numerous peer-reviewed research papers and an internationally recognized speaker on the ontogeny of flavor preferences and its implications for health and nutritional programming.

Danielle R. Reed
Associate Director, Monell Chemical Senses Center
Ph.D., Psychology; Yale University (USA)

We do studies to understand the exact relationship between genotype and phenotype in both animal models and in human subjects including twins. Phenotypes of interest include taste perception, food preferences and obesity.

Johannes Reisert
Ph.D., Physiology; University of Cambridge (UK)

My laboratory investigates one of the first steps in olfactory perception: the conversion of an odorous stimulus into a nerve signal. Olfactory receptor neurons located in the nose detect odorants and generate the electrical response, which is then conveyed to the brain for further processing. The focus of my research is to understand 1) how olfactory receptor neurons code odor signals of different odorants and, 2) the cellular mechanisms that lead to the generation and termination of those responses. We also are interested in investigating the contribution of olfactory receptor neurons to olfactory adaptation, which is the waning of our perception of odorants over time. My approach uses both electrophysiological and cell imaging techniques to address these questions.

Michael G. Tordoff

Ph.D., Physiological Psychology; University of California, Los Angeles (USA)

My research interests are broadly focused on taste and nutrition. One area involves topics related to mineral appetite, including calcium taste and appetite, the physiology of salt intake, appetite specificity, and how the postingestive consequences of minerals influence taste preferences. Another area involves the genetics of taste perception, including the preferences for alcohol, sweetness, saltiness and calcium. A third area involves characterizing the environmental contribution to individual differences, particularly the influences of early environment, husbandry procedures, and food choice on taste preferences and dietary obesity.

Associate Members

Peihua Jiang

Ph.D., Neurobiology; University of Pittsburgh (USA)

Until recently, it was thought that all mammals can detect the five basic tastes that humans can. Our work and others have shown that there are many exceptions to this general belief. Many mammalian species show specific taste loss due to the pseudogenization of taste receptor genes and loss of taste receptor function appears directly related to a change in diet. Understanding the precise relationship among taste receptor structure, dietary choice and the associated metabolic pathways constitutes one of my two main research interests.

The other line of my research aims to study adult taste stem cells. Taste cells regenerate constantly during an animal's life, yet the identity of adult taste stem cells for replenishing taste epithelium remains elusive. I am interested in identifying reliable markers for adult taste stem cells and characterizing such cells subsequently. Current research projects include: 1) structure-function analysis of the mammalian sweet taste receptor T1R2/T1R3; 2) comparative genetics of sweet taste and carbohydrate metabolism in Carnivora; and 3) identification and characterization of adult taste stem cells. We utilize a broad range of approaches in these studies, including molecular, genetic, cellular, computational and imaging techniques.

Johan Lundström
Ph.D., Psychology; Uppsala University (Sweden)

My research is aimed toward a better understanding of the cerebral basis for chemosensory and multimodal processing. Several different lines of ongoing research explore how the human brain allows us to perceive, process, and understand chemosensory and multimodal information. In particular, our lab is concerned with the complex processing of social chemosignals, signals that act along the border between perception and cognition. Lately, we are also investigating the neuronal basis of multimodal processing using our chemical senses, a natural multimodal sensation, as a stepping board.

Ichiro Matsumoto
Ph.D., Molecular Biology; University of Tokyo (Japan)

My primary research interest is the coding mechanism of taste modality, specifically whether gustatory neurons are heterogeneous or homogeneous. Also, I am interested in the turnover of taste receptor cells and establishment and maintenance of peripheral gustatory wiring between taste receptor cells and gustatory neurons.

Nancy Rawson
Associate Director and Vice President, Monell Chemical Senses Center
Ph.D., Biology; University of Pennsylvania (USA)

The health of the biological systems we use for detecting tastes and odors is paramount to insure optimal health and well-being, and these systems are now known to be used not only for sensing the external environment but the internal chemical milieu as well. Their importance for survival is underscored by their remarkable regenerative ability, which helps to insure function in the face of exposure to harsh environments, whether externally facing in the nose or mouth, or internally facing, such as in the GI tract or lung. Cell-based tools are used to understand the development and function of chemosensory receptor cells and to leverage this understanding through multidisciplinary collaborations to address health challenges in the prevention and management of health conditions related to weight management and metabolic status, aging and neurological disorders.

Hong Wang
Ph.D., Molecular Biology; Yale University (USA)

Chemosensory disorders substantially impact the quality of life. Impairment of taste and smell contributes to malnutrition, cachexia, and depression in a large percentage of cancer and AIDS patients. In spite of the rapid progress in identifying chemosensory receptors and signaling molecules, the mechanisms of chemosensory disorders remain largely unknown and there is a lack of specific and effective treatment for these disorders. Thus, the primary focus of our laboratory is to identify the molecular and cellular mechanisms underlying chemosensory disorders.

Our current research projects include: 1) taste abnormalities in animal models of inflammatory diseases; 2) expression and signaling of inflammatory cytokines and innate immune receptors in the chemosensory systems; 3) regulation of taste bud degeneration and regeneration; 4) mechanisms of taste loss during cancer chemotherapy; 5) interactions between inflammatory and taste receptor-mediated signaling pathways in the gut.

Paul M. Wise

Ph.D., Psychology; University of California, San Diego (USA)

Chemical irritation constitutes a continuing focus. In particular, I am interested in how nasal irritation changes over time in the face of steady stimulation, and how one may trade time and concentration to maintain a constant level of detectability to understand how the sensory system integrates over time. Other interests include perception of carbonation, and chemical stimuli as triggers of cough. Within the area of olfaction, my primary interest is mixture interactions in odor detection. An additional interest that cuts across sensory modalities is in methods to measure sensory thresholds.

Assistant Members

Amber Alhadeff

Ph.D., Psychology; University of Pennsylvania (USA)

What controls hunger? How do we know when we are full? And how does what we eat influence our brain activity? Maintaining balance between nutrient need and consumption requires exquisite coordination between the gut and the brain.

The Alhadeff Lab is interested in understanding how gut-brain connections, and activity across circuits in the brain, influence motivated behavior. Our research employs a combination of modern neuroscience tools and surgical approaches to understand how external stimuli (e.g. food and drugs) affect in vivo neural activity, and how this brain activity drives behavior.

Kevin Bolding

Ph.D., Neuro and Behavioral Science; SUNY Downstate Medical Center (USA)

In the Bolding Lab, our goal is to discover fundamental rules and mechanisms that govern information storage and retrieval in neural systems. Our primary focus will be establishing the changes in neural circuit and population dynamics that correspond to odor recognition memory. To bring our understanding of this process to a new level of rigor we will apply quantitative statistical approaches to relate behavioral signatures of odor recognition to activity and plasticity in olfactory circuits. We will use in vivo electrophysiology and calcium imaging to capture the activity of large neural populations during olfactory experience, and we will apply cell-type specific perturbations of activity and plasticity to discover how specific circuit connections contribute.

Valentina Parma
Assistant Director, Monell Chemical Senses Center
Ph.D., Experimental Psychology; University of Padova (Italy)

I am a psychologist interested in human olfaction across the lifespan. Both my basic and translational work aims at finding ways to use smell as an opportunity to improve health. I use behavioral and physiological methods to understand how odors influence typical and atypical behavior. Recently, I have been chairing the Global Consortium for Chemosensory Research (GCCR) to understand how smell, taste and chemesthesis are affected by COVID-19 and other respiratory disorders, I have co-developed smell tests to facilitate awareness of chemosensory loss and distortion, and I am working to bring new solutions to favor chemosensory recovery.

Yali V. Zhang
Ph.D., Biochemistry, Cellular and Molecular Biology; The Johns Hopkins University School of Medicine (USA)

The research goal of my laboratory is to address how animals sense the complex food environment to control feeding behaviors. To tackle these big questions, we use model organisms such as the fruit fly to identify the receptors or channels in the peripheral taste organs that enable animals to sense different features of food such as the chemical composition, food texture and food temperature. Furthermore, we investigate the physiological functions of sensory cells or neurons that allow animals to detect the chemical and physical stimuli from the food landscape. Moreover, using the functional Ca2+ imaging, optogenetics and electrophysiology, we map the neural circuit in the brain that decodes the external food environment. In summary, we aim to unravel how the brain integrates different types of sensory modalities such as the chemosensory and mechanosensory stimulation, in order to make appropriate feeding decisions.

Adjunct Faculty

Noam Cohen, Adjunct Member

MD, Johns Hopkins University; Ph.D. Neuroscience; Johns Hopkins University
Associate Professor, Otorhinolaryngology, University of PA School of Medicine
Staff Surgeon, Philadelphia Veterans Administration Medical Center

The main interest of my lab is the pathophysiology of chronic rhinosinusitis, a syndrome that affects nearly 15% of the population manifesting in poor mucus clearance from the upper airways. To better understand the root cause of this syndrome, the focus of my laboratory has been on sinonasal epithelial function in the context of innate defense mechanisms, specifically mucociliary clearance and alterations in respiratory cilia function in response to microbial interactions and mucosal biofilm formation. To this end we have well-established and published techniques for growing both upper and lower respiratory epithelium from humans, visualizing and quantifying respiratory cilia function, live cell imaging to ascertain real time alterations in signaling cascades such as intracellular calcium and nitric oxide as well as other cellular properties (e.g. intra- and extra-cellular pH and cellular redox states), mucus clearance and hydration and techniques for growing and studying several respiratory pathogens. Most recently we have focused on the role that taste receptors, which are expressed in respiratory epithelium, play in upper airway innate immunity. The overall goal of my work, both in the clinical and research realms, focuses on understanding and treating disorders of the nose and paranasal sinuses. It is through this balance of clinical expertise and biological investigation that I hope to advance the care of rhinologic patients.

Yuzo Ninomiya, Adjunct Distinguished Member

Ph.D., MD.Sci; Nagoya University (Japan)
Distinguished Professor at Kyushu University

Using electrophysiology and molecular biology we are seeking to understand the coding mechanisms underlying salty, umani (savory) and sweet taste qualities. We are also studying how hormones regulate taste responses. My group has found that hormones including leptin and endocannabinoids modulate peripheral sweet taste responses. Our studies show that modulation of peripheral sweet taste signaling by hormones likely contributes to the regulation of ingestive behavior.

Luis Saraiva, Adjunct Associate Member

Ph.D., Genetics; University of Cologne (Germany)
Investigator – Associate Level, Sidra Medical and Research Center, Qatar

Humans, like most animals, display complex behaviors and social structures. Complex behaviors are highly variable between individuals, resulting from the interplay between an individual's innate qualities, internal homeostatic state, and experiences with the surrounding environment. Despite being a very active field of study, the neurobiological basis of complex behaviors (and how it can lead to changes that ultimately may result in disease or mortality) still remains one of the greatest unanswered questions in modern neuroscience. Understanding how environmental and homeostatic cues interact with sensory systems is crucial to unravel the neural mechanisms underlying the behavioral and physiological responses these cues can elicit.

Broadly, we are interested in the molecular and neural mechanisms underlying the transformation of environmental and homeostatic cues in complex behaviors and physiological changes. In this context, a major line of research in our lab involves how the olfactory, metabolic and appetite systems interact, and how these interactions change with diet and disease. We also aim to understand how individual genetic variation, gender, age, and social experience impact these mechanisms. Another major line of research focuses on the molecular and functional logic underlying the rigid spatial organization of the main olfactory system. To achieve these goals, we employ a multidisciplinary experimental approach combining conventional techniques and novel technologies.

Furthermore, we are using “omics" technologies to find biomarkers and link specific variants to complex traits and/or diseases involving olfactory phenotypes (e.g. obesity, anosmia/hyposmia, Kallman Syndrome, Alzheimer’s disease and others). To this end, we are analyzing human samples and data from countries around the world.

Our ultimate goal is to use these results to learn more about the molecular and functional mechanisms underlying olfaction, and to identify biomarkers that can help us predict the onset and progression of certain illnesses.

Senior Research Associates

Linda J. Flammer

Ph.D., Psychology; Temple University (USA)

My primary research interest is in creating a better understanding of the interrelationship among the sensorial, cognitive, metabolic and genetic influences on human ingestive behavior. I am particularly interested in sweetness and bitterness perception and discovering ways to modulate them. Further, having started my career at Monell investigating chemesthesis, the topic is still near and dear, especially mouthfeel. The goal of this research is to help stem the global obesity epidemic by enabling the creation of healthier foods and beverages without compromising on their palatability. Finally this work also identifies solutions to make bitter medicines more palatable, with the hope of increasing patient compliance, especially among children suffering from life-threatening illnesses.

M. Hakan Ozdener

M.D., Ondokuz Mayis University, Samsun (Turkey); Ph.D., Biochemistry; Ondokuz Mayis University (Turkey);   MPH (Public Health); Temple University (USA)

My primary research focuses on the development of in vitro chemosensory cell culture systems for the study of chemosensory biology and disorders. I utilize chemosensory cells obtained from human and from rodent to examine the factors involved in differentiation and maturation and to better understand how chemosensory receptor cells interact in their responses to stimuli. This work will enable us to develop and characterize novel tastent and new therapeutic targets to promote regeneration following injury from surgery, radiation, toxic exposures or deterioration due to aging or neurodegenerative disease.

Michael Napolitano

Ph.D., Analytical Chemistry; University of Florida (USA)

Mass spectrometry is arguably the most important analytical technique considering its selectivity, sensitivity, and informing power, among other qualities. I have sought to apply mass spectrometry's capabilities throughout my various research endeavors, which include analyzing pigments and dyes from works of art, absolute quantitation of food extracts, and lipid profiling. With my postdoctoral experience at the Hollings Marine Laboratory, I honed my interests on lipids by incorporating the relatively new field of untargeted analyses using high resolution mass spectrometry to decipher the entire lipidome of various biological samples (plasma, muscle, liver, brain) for aquatic specimens (saltwater fish, sea turtles) and marine mammals (bottlenose dolphins, Florida manatees). Lipidomics may provide unparalleled structural information regarding the content of intact lipids of a sample across lipid category (e.g., glycerophospholipid), class (e.g., phosphatidylcholine, PC), and species (e.g., PC 16:0_18:1). An additional interest of mine is fatty acid profiling, which uses a gas chromatograph with either a flame ionization detector (GC-FID) or mass spectrometer (GC/MS) to provide increased structural information of fatty acids (i.e., double bond position and *cis/trans* conformation). I am excited for my prior skills to be combined with untargeted metabolomics and analysis of volatiles, among other techniques, at the new George Preti Research Support Core for Analytical Chemistry.

Catherine Peyrot Des Gachons

Ph.D., Medical and Food Sciences; Université de Bordeaux (France)

My research interests are human oral perception, its genetic basis and its implications in nutrition and health. Somatosensation, such as irritation and mouthfeel, is my main current focus through the study of natural products like wine, olive oil and spices. I am using several techniques to investigate the field of somatosensation, including molecular biology, cellular calcium imaging and psychophysics.

Karen K. Yee
Ph.D., Physiology; Virginia Commonwealth University (USA)

My research interest is in taste mechanisms, utilizing various methods (i.e., immunohistochemistry) to identify novel pathways in mammalian and human taste cells. Findings will provide additional knowledge about which components help modify taste sensitivity and function and their roles in gustatory function, appetite, satiety, diabetes and obesity. Another research interest is in the plasticity of the mammalian olfactory system.

Research Associates

Federica Genovese
Ph.D., Neuroscience; University of Heidelberg (Germany)

In the mammalian nose, the trigeminal system detects irritants and the olfactory system detects odorants. Traditionally, these systems have been considered separate sensory modalities, but a more complex picture has recently emerged. Psychophysical and electrophysiological studies show evidence of interaction between these two chemosensory systems, suggesting that olfactory perception is the result of olfactory-trigeminal integration, rather than an isolated system.Although most odorants can also activate the trigeminal system, and most irritants can also be detected by olfactory sensory neurons, the nature of olfactory-trigeminal interaction is still unclear.

I am interested in investigating the mechanisms underlying the interaction of the trigeminal and olfactory chemosensory systems during the detection of volatile irritants, with a special focus on the role of solitary chemosensory cells (SCCs), specialized chemosensitive nasal epithelial sentinel cells.

Cristina Jaén
Ph.D., Medical Sciences, Physiology; University of South Florida (USA)

My research interests focus on how odorant perception affects human psychological and physiological responses. Many organic volatile compounds can elicit an odorant and irritant response. Olfactory cues such as smoke or rotten food alert us from perils and may produce an anxious reaction. I am interested in understanding how odorant perception affects different subpopulations, e.g. asthmatic subjects (who have respiratory problems) versus non-asthmatic subjects. This research may lead to a better understanding and management of asthma after being exposed to perceived dangerous odorant stimuli.

Akihito Kuboki

M.D.; St. Marianna University School of Medicine (Japan)

My research interests are to understand the mechanisms of adaptation in olfactory sensory neurons to an odorous stimulus and the factors involved in homeostatic regeneration of the olfactory epithelium. By investigating the first step of olfactory perception, I want to investigate the pathophysiology of olfactory dysfunctions in the periphery. I will use electrophysiological as well as cell biological approaches to address these questions.

Young Eun Lee

Ph.D., Organic Chemistry; University of Pennsylvania (USA)

My research is focused on identifying the volatile biomarker signature of ovarian cancer in human plasma. Controlled studies demonstrate that dogs can detect ovarian cancer samples from normal ovarian samples with above 95% success rate by using their highly developed sense of olfaction. We will determine the most prominent volatile organic compounds (VOCs) of the unique order signature of early stage ovarian cancer using analytical organic chemistry. Gas chromatography-mass spectrometry (GC/MS) techniques are ideal for identification and quantification of mixtures of VOCs found in the cancer sample. Our ultimate goal is development of a practical diagnostic system for early stage ovarian cancer to save people from the deadliest gynecologic oncology.

Brian Lewandowski

Ph.D., Neuroscience; University of Pennsylvania (USA)

My research is focused on understanding the cellular and molecular basis of salty taste. There are at least two pathways underlying salty taste in mammals, distinguished by their sensitivity to the cation channel inhibitor amiloride. While much has been learned about these pathways, some important questions remain unanswered. What types of taste cells express salt taste receptors? What is the identity of the receptor/channel responsible for amiloride-insensitive salt taste? How does cell-to-cell communication within the taste bud influence salt signal transduction? My goal is to help answer these and other questions related to salt taste transduction. My experiments combine physiological analyses of taste cells using calcium imaging and electrophysiology with single cell molecular techniques to assay gene transcription.

Prior to coming to the taste field, I used in vivo electrophysiology in awake, behaving animals to study the systems and neural networks underlying vocal communication. This background in neural networks fuels my broader interest in understanding how cell-to-cell communication in the taste bud shapes taste signal transduction and mediates the perceptual interactions between different taste qualities. My focus on salty taste is motivated by evidence from perceptual and physiological studies that suggest cell-to-cell signaling plays a particularly important role in salt taste transduction.

Cailu Lin

Ph.D., Animal Genetics; Rheinische Friedrich-Wilhelms University of Bonn (Germany)

My research focuses on the genetic analysis of complex traits, such as taste perception and obesity in mice and humans. I participate in collaborative studies in the laboratories of Drs. Bachmanov and Reed. The objective of these studies is to identify the chromosomal locations of the genes associated with these quantitative trait phenotypes. The ultimate goal of my studies is to identify genes that are involved in taste perception, alcohol consumption, and obesity. To achieve this goal, I study genotype-phenotype associations in humans, breed and analyze various consomic and congenic mouse strains, and use a combination of physiological, molecular, and quantitative genetic approaches.

Jiang Xu

M.D., Medicine; Beijing Medical Staff College (China)

My current project mainly focuses on studying cellular responses to volatile chemical stimuli. I use fluorescence imaging of intracellular calcium and pharmacological agents to characterize the transduction processes in live olfactory and trigeminal neurons.

Postdoctoral Fellows

Sam Bacharach

Ph.D., Neuroscience; University of Maryland, Baltimore (USA)

A primary reason we eat is to fulfill a homeostatic need to obtain calories and alleviate the aversive experience of hunger. However, eating also occurs because it is pleasurable and rewarding, even when we don’t physiologically need the calories. I am interested in understanding how signaling in homeostatic and reward centers of the brain drives these two distinct motivators of feeding behavior. Further, I am interested in exploring how individual differences in feeding behavior and obesity are mediated by the influence of gut-brain communication on sensory processing and learning about food-related cues. To this end, I combine in vivo neural activity monitoring with state-of-the-art gut and brain manipulations to investigate how homeostatic and reward systems influence feeding behavior and motivation.

May Cheung
Ph.D., Nutrition Sciences, Drexel University (USA)

My research interest is to understand the interplay between taste preferences, energy metabolism and obesity in humans. Overconsumption of high-caloric, low-micronutrient foods can lead to dysregulation of energy-regulating hormones, contributing to obesity and related chronic diseases. Food choices are strongly influenced by hedonic responses to preferred foods. Therefore, taste preferences play an important role in forming a healthy dietary pattern. Furthermore, emerging evidence suggests that increase in carbon dioxide in the atmosphere can lead to lower concentrations of protein and minerals in crops, further contributing to the obesity/malnutrition paradox. My goal is to explore the feasibility of taste adaptation to sustainable, nutrient-dense novel foods and subsequent health effects in humans.

Mackenzie Hannum
Ph.D., Food Science & Technology; The Ohio State University (USA)

My research interest involves understanding how and why people perceive taste and smell the way they do. There is a physiological component to perception, driven by different mechanisms and structures, but there is also a psychological component that can be heavily influenced by past and current experiences. In trying to better understand the interplay between the two on an individualized level, I am interested in employing novel methodologies and data analysis techniques to capture this information.

Therefore, my main research aim is to employ the Monell Flavor Quiz to collect information on taste and smell on a global scale – distributing the quiz to individuals across the world. And there is nothing more individualized than knowing someone's DNA. By collecting saliva samples along with their answers to the Monell Flavor Quiz, we are able to investigate the relationship between someone's DNA and their perception and preference of different tastants and odorants. This information allows us to assess global food preferences underscored by the interplay between someone's genetic makeup and any psychological influences on their perception such as liking or engagement with the task.

Kuei-Pin Huang
Ph.D., Physiology; University of California, Davis (USA)

Food consumption induces the release of gut signals that are locally sensed by the gastrointestinal tract-innervated peripheral nerves. These signals are rapidly conducted to the different brain regions, which modulate the eating behaviors.

My research interest is in understanding how different nutrients (sugars, fat, and proteins) are sensed by the peripheral nervous system and how these different signals modulate food intake in physiological and disease stages. We use different mouse models and the latest neuroscience tools to record in vivo neuronal activity and manipulate the specific population of neurons to reveal the potential target for eating disorders.

Stephanie Hunter

Ph.D., Nutrition; Purdue University (USA)

It is clear that people choose diets because of their sensory properties. Further, an enjoyable sensory experience is essential for adherence to any dietary regimen. My research interests lie in understanding how the chemical senses contribute to food choice and eating patterns, with the aim of developing strategies to alter the sensory properties of the diet to better align with dietary recommendations. I am specifically interested in understanding how to practically alter food preferences through sensory manipulation and sensory influences on appetite, ingestive behavior, metabolic outcomes, and risk for chronic disease. Alternatively, I am interested in understanding the impact of COVID-19 on taste and smell, and how lack of taste or smell influence food choice and eating patterns.

Chanyi Lu

Ph.D., Microbiology; Fudan University (Shanghai, China)

Tuft cells are chemosensory cells in the intestinal epithelium which express a number of taste-signaling elements. Despite being discovered decades ago, the function of tuft cells in the small intestine was only recently discovered. Tuft cells mediate host defense against parasitic infection or other pathogens by regulating type 2 immunity. My research interest is clarifying the parasites' ligands and sensing receptors in tuft cells.

Ting-Wei Mi

Ph.D., Plant Science; China Agricultural University (China)

Taste is a fundamental sense required to perceive food flavor including food taste, texture, temperature, etc. To unravel how animals detect the physical and chemical information from the food environment, we use model organisms such as the fruit fly and mouse to explore the peripheral and central gustatory mechanisms that regulate food preference and feeding behavior.

Ha Nguyen

Ph.D., Food Science and Technology, University of Alberta (Canada)

I am interested in the influence of person-to-person differences on chemosensory perception and food preference and how genetic variation explains the individual differences in the sense of taste and smell. Consumer segmentation has been my favorite analysis to understand consumers' sensory perception and food preference over my past research. However, the differences in food sensory perception between consumer segments were not well interpreted in previous studies although individual influences such as demographics, chemosensory ability, and food consumption habits were incorporated in those studies. The individual differences in chemosensory perception may be explained by genetic variation. My current research focuses on the connection between genetic ancestry and bitter perception and the efficacy of bitter blockers. Understanding chemosensory and hedonic biomarkers will offer great support for improving the health and well-being of specific populations as well as the development of medicine and food products.

Robert Pellegrino

Ph.D., Food Science; University of Tennessee (USA)

My interests are to understand and predict behavioral responses to odors. In naturalistic settings, odors are composed of numerous odorants that are carried in plumes. At Monell, the focus of my work is to predict odor mixture perception and behavioral outcomes based on structural characteristics of the constituent odorants. Our first aim is to collect reliable and valid human sensory data for a large set of odor mixtures at different concentration ratios. This information, combined with physicochemical and structural variables, will help us build predictive models that can be used with behavioral measurement tools to understand outcomes to naturalistic odors.

Alyssa Smethers

Ph.D., Nutritional Sciences; Pennsylvania State University (USA)
R.D., Nutrition; Marywood University

Prior to coming to Monell, I conducted a series of controlled feeding studies testing how environmental factors, particularly portion size and energy density, and individual differences influence preschool children’s energy intake over time. At Monell, the goals of my research are to build upon this knowledge and develop a broader understanding of how individual differences contribute to preferences and appetite. I’m particularly interested in the relationship between a person’s genes and their taste preferences (e.g. sweet and bitter) and how this influences ingestive behavior.