Computational Gastronomy

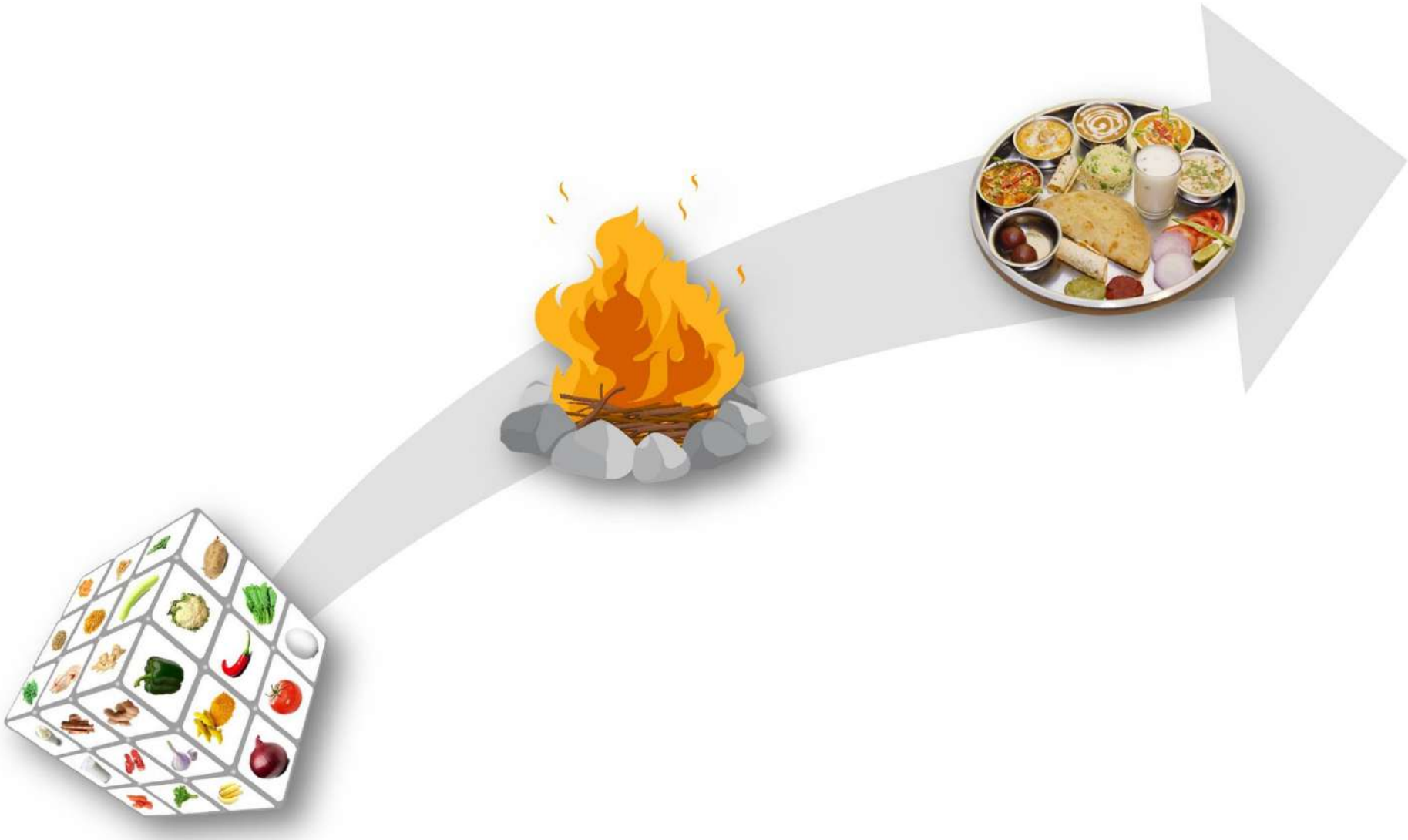
GANESH BAGLER

Complex Systems Laboratory

http://cosylab.iiitd.edu.in

The emerging data science of food, flavors, and health

Computational Gastronomy is a data science that blends food, data, and computation for data-driven food innovations



Cooking is alchemy

Cooking: Central to evolution of human brain

Cooking is the essence of being human

'Catching Fire—How cooking made us human' by Richard Wrangham

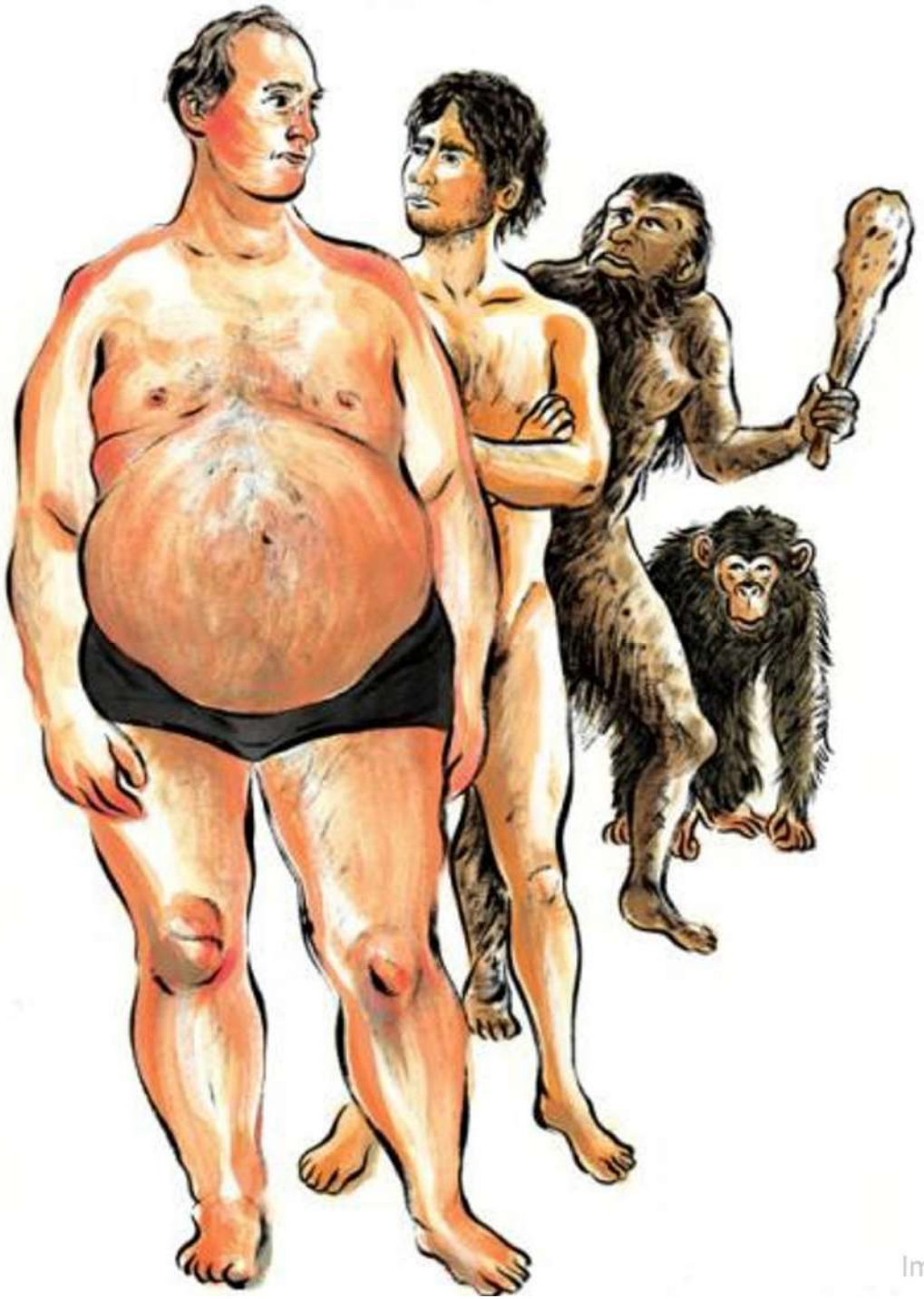


Image Credits: Chloe Cushman

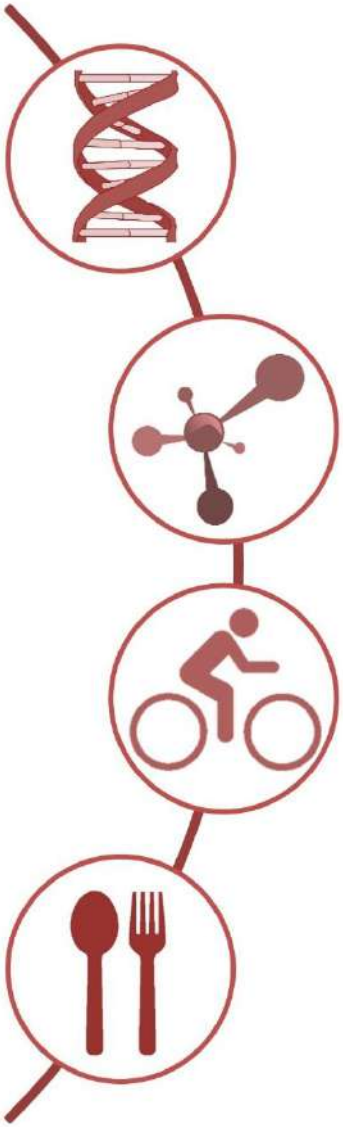
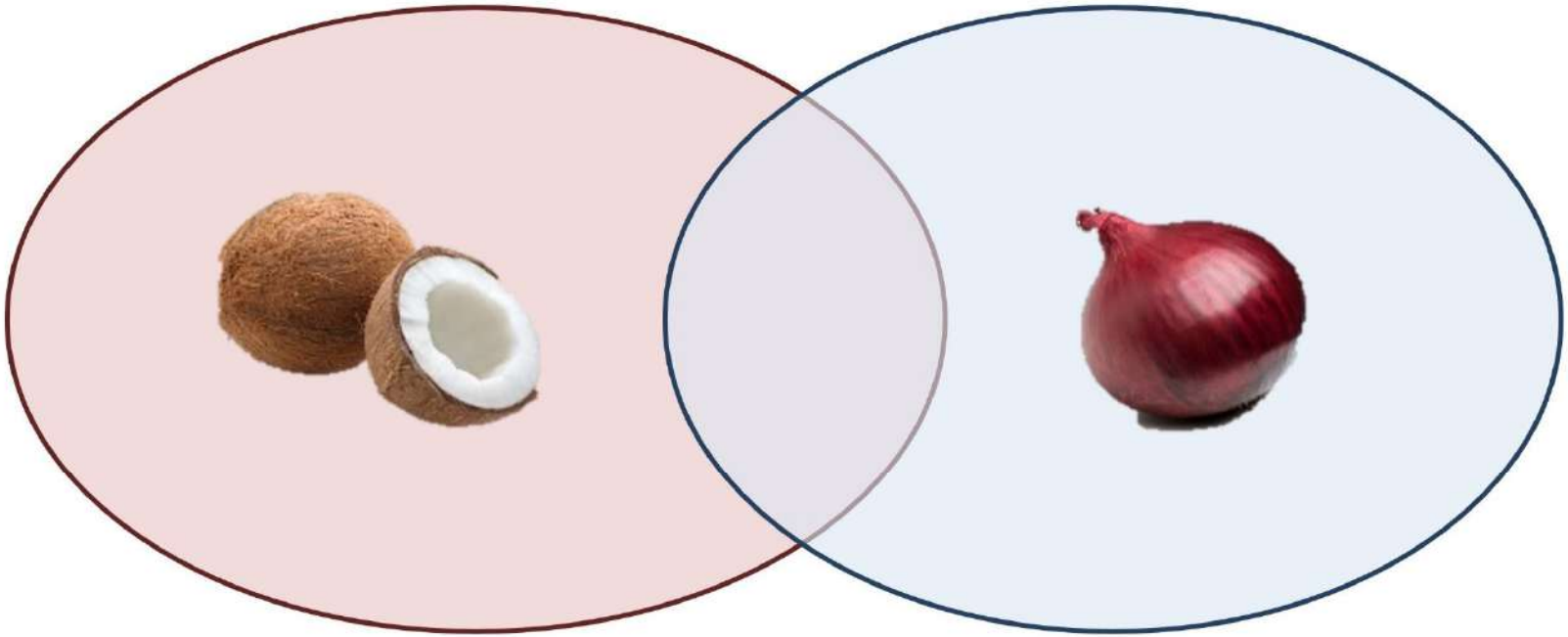


Image Credits: Chloe Cushman

Why do we combine ingredients in our recipes the way we do?

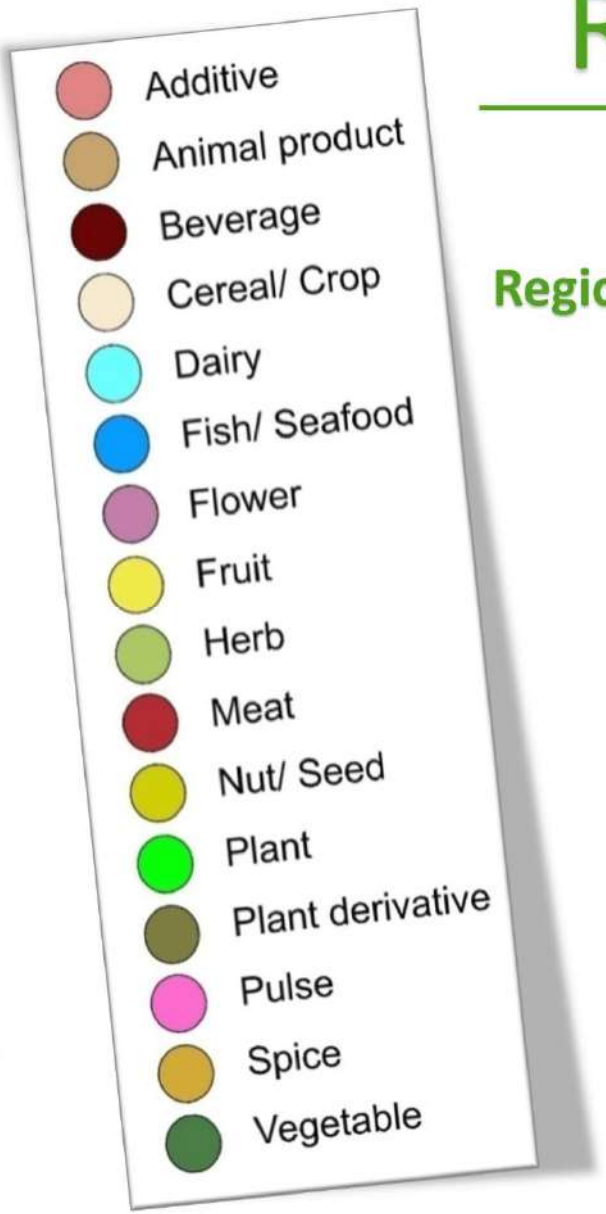
Food Pairing Hypothesis

Ingredients that **taste similar** tend to be **used together** in traditional recipes



Ahn *et. al*, "Flavor network and the principles of food pairing", Scientific Reports (2011).
A Jain, NK Rakhi, G Bagler*, "Spices form the basis of food pairing in Indian cuisine", **arXiv**:1502.03815 (2015).

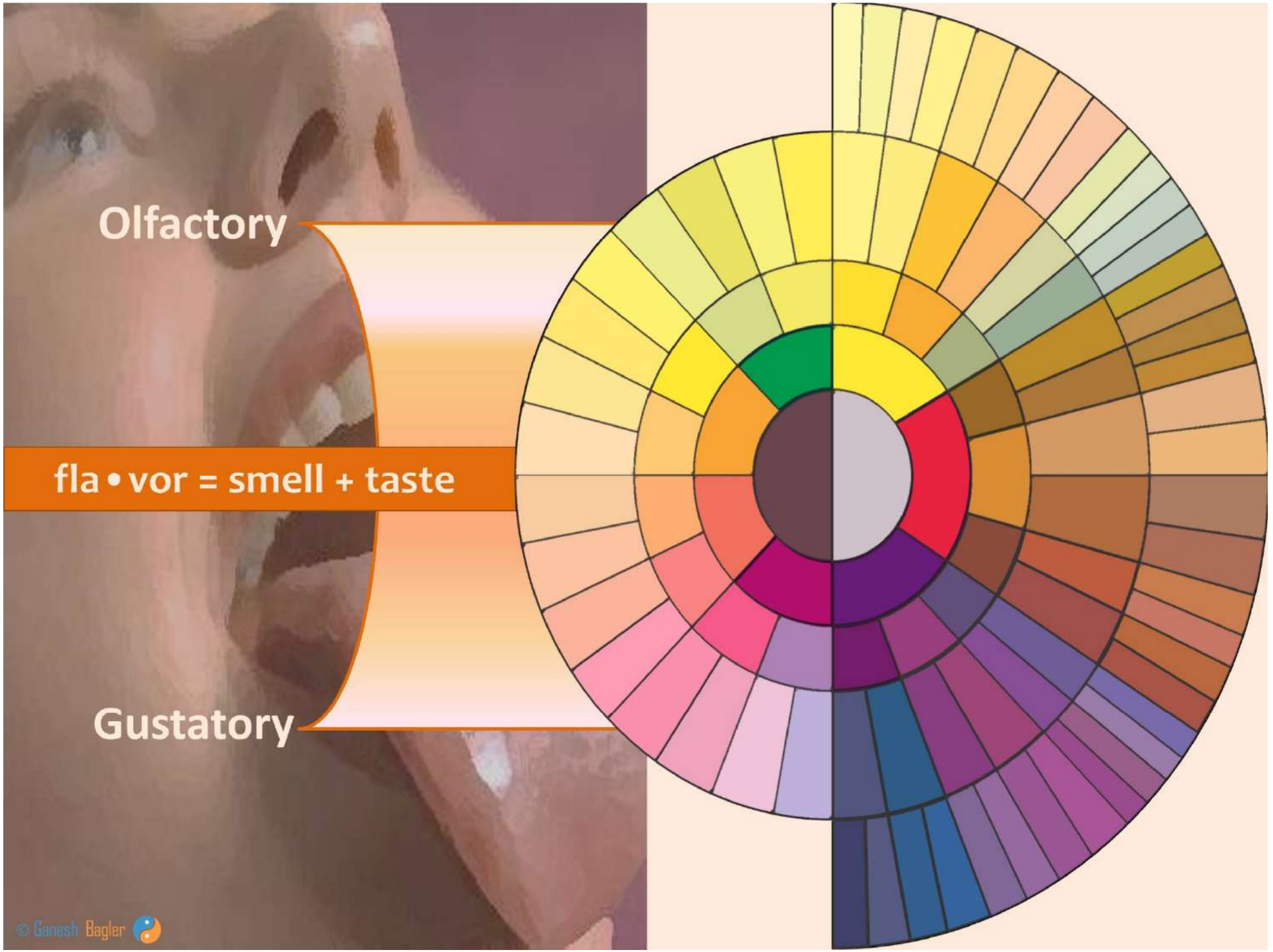
Recipes & Ingredients

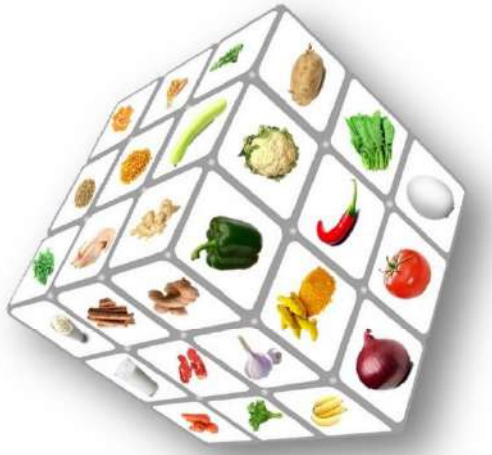


2543 Traditional Indian Recipes (TarlaDalal)

Regional cuisines: Bengali, Gujarati, Jain, Maharashtrian, Mughlai, Punjabi, Rajasthani, South Indian.

A Jain, NK Rakhi & G Bagler,* "Analysis of Food Pairing in Regional Cuisines of India", **PLoS ONE**, *10(10): e0139539*(2015).

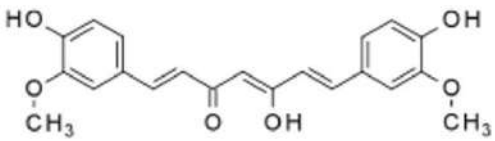

Olfactory
fla • vor = smell + taste
Gustatory
© Ganesh Bagler

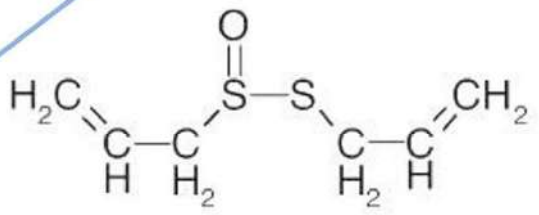


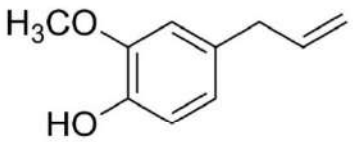
PubMed

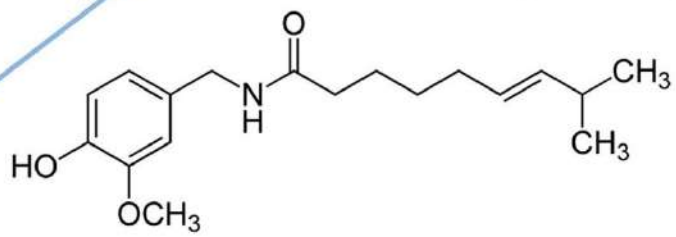
PubChem

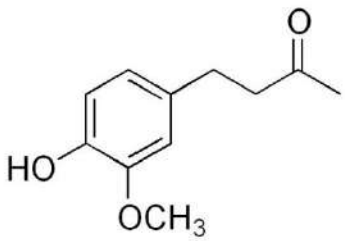
Fenaroli's Handbook

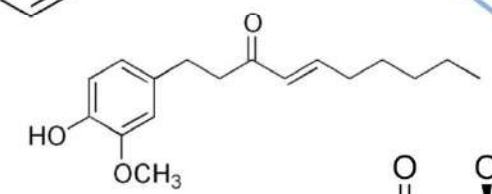


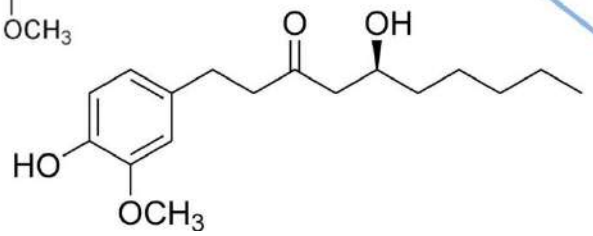




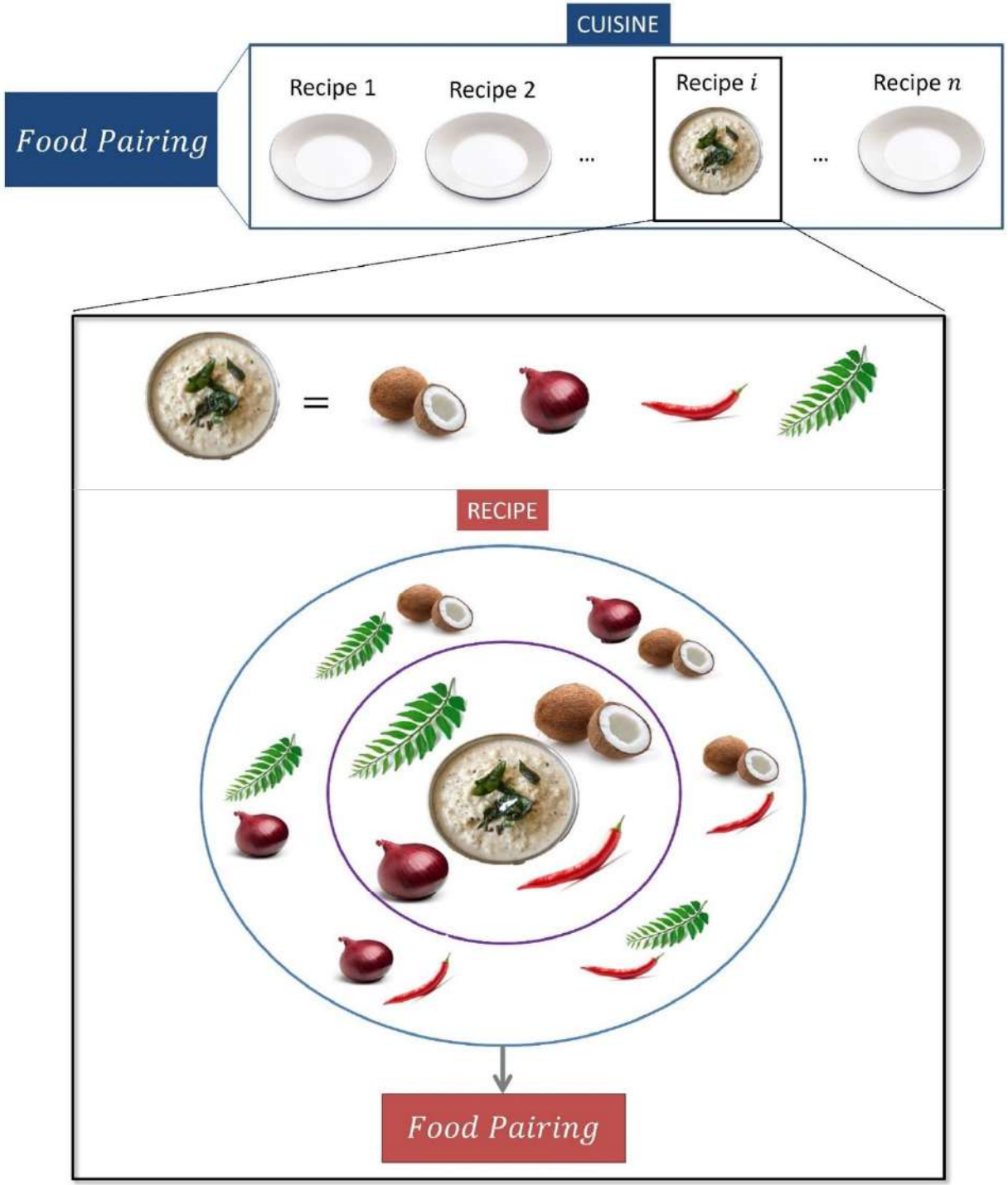


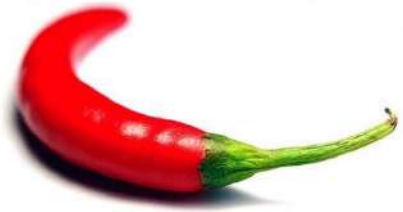






Food Pairing





Spice

The Taste of India

Anupam Jain, NK Rakhi and Ganesh Bagler*, **arXiv** (2015); Anupam Jain, NK Rakhi and Ganesh Bagler*, **PLoS ONE** (2015).

Culinary Fingerprints

Anupam Jain, NK Rakhi and Ganesh Bagler*, **arXiv** (2015); Anupam Jain, NK Rakhi and Ganesh Bagler*, **PLoS ONE** (2015).

A View from **Emerging Technology from the arXiv**

Best of 2015: Data Mining Indian Recipes Reveals New Food Pairing Phenomenon

By studying the network of links between Indian recipes, computer scientists have discovered that the presence of certain spices makes a meal much less likely to contain ingredients with flavors in common. From February ...

December 30, 2015

MIT Technology Review

Best of 2015
MIT Technology Review

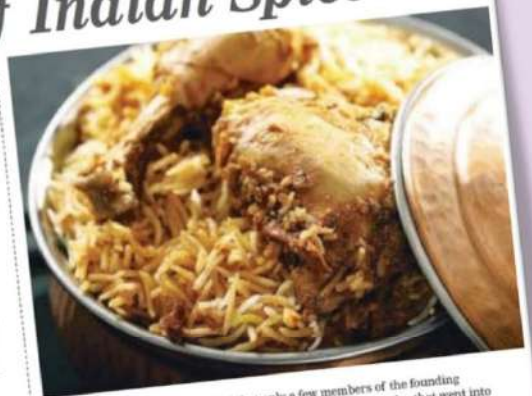
Anupam Jain, NK Rakhi and Ganesh Bagler*, **arXiv** (2015); Anupam Jain, NK Rakhi and Ganesh Bagler*, **PLoS ONE** (2015).

vir sanghvi

rude food

The Magic Of Indian Spices

Dishes like pilaus may have come to us from West Asia, but it was India's spice magic that raised them to another level entirely



SPICED UP Kebabs and pilaus may have come to India from the Middle East, but biryani, I think, is our own creation

Many years ago, I wrote that some of the food of Central Asia and the Middle East was a rough draft for Indian cuisine. This led to (understandable) outrage and claims that I had ignored the contribution of foreign visitors of our cuisine.

What about kebabs, I was asked? Weren't they a Middle-Eastern invention? What about the samosa? Arabs brought it to India and variations of the original samosa (under such names as *sambusak*) can still be found all over West Asia.

And then there was the big one: pilaus.

Didn't I realise that the first pilaus came from Turkey and other Middle Eastern countries? Why was I going on and on about biryani's Indian flavours when it was clear that the dish came to India with Arab armies? And so on.

My answer has always been that while I have huge respect for the cuisines of West Asia, they have always struck me as lacking the depth of Indian cuisines. (Yes, yes: I concede that I haven't travelled through the whole of the Middle East and that, as an Indian, I am not exactly an unbiased or disinterested observer.)

I do not dispute that samosas, kebabs and pilaus came to India from the Middle East. (Though biryani, I think, was our own creation.) But I believe that these dishes were raised to the next level of complexity and sophistication because of India's secret ingredient.

Spice.

Any Indian who eats a Middle Eastern kebab or pilau will find it bland and unsophisticated because it will not have the complicated spice flavours that are the hallmark of good Indian food. My view is that yes, these dishes came to us from West Asia but it was India's spice magic that raised them to another level entirely.

Great Indian food is all about spices. Do you know of any other country where so many of the great chefs will refuse to part with the secret spice mixture that goes into each dish?

It's not just kebabs and pilaus. Go to any traditional restaurant anywhere in India and you will never be able to get the chefs to reveal what the exact proportion of masalas is. When fancy restaurants hire traditional chefs, they are shocked to discover that the chefs will make their masala mixes at home and will come to the kitchen with little packets of ready-made spice mixes.

Nor is this restricted to North Indian food. I once shot a TV programme at Muthu's Curry, the famous fish head curry restaurant in Singapore. It turned out that only a few members of the founding family knew the exact proportion of masalas that went into the curry. Each morning, a family member would come and make the curry masala in secret. The cooks would have to use that masala and would never learn what it was that made the famous curry so special.

Take away the spices and most Indian food loses its distinctive identity. The reason why a Turkish pilau pales before a Lucknawi pilau is because the man who made the Lucknawi dish used spices. Compare any minced meat kebab from the Middle East to a *shami* kebab (let alone a *galouti* or a *kakori*) and the Indian kebab will always have a more complex taste because the Indian *kebabchi* has used complex spicing.

Many people in the Middle East (and the West) disagree violently with me. Some suggest that I am making too much of the spice factor. If a pilau has meat and rice, then surely it is the same dish everywhere, even if the Indian version has a little more spice, they argue.

So I was relieved last week to meet up with Dr Ganesh Bagler who has spent many years researching the science of Indian food along with many enthusiastic and gifted students and collaborators.

Dr. Bagler specialises in flavour molecules. This is an area of great

FOOD GURU Dr Ganesh Bagler has researched food for many years and has concluded that spices are the key ingredients of Indian food

Photo: RAJ K RAJ

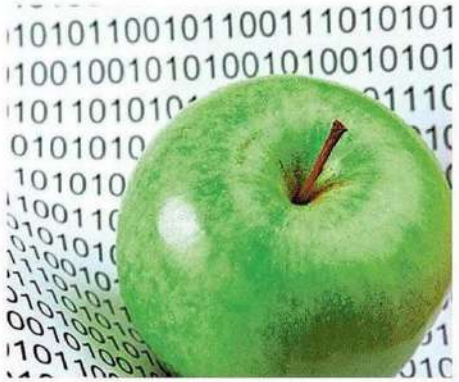
MICRO-CHIPS

THE HINDU

The scoop on computational gastronomy

2019 will observe food culture having a heightened taste for tech and data too

:: SUNALINI MATHEW



A bite out of data Computational gastronomy is designing the future of food •SPECIAL ARRANGEMENT

Food, nutrition, culture, heritage. At the upshot, computational gastronomy brings all of these together to record recipes, track ingredients, and make insightful deductions of what we eat traditionally, and "why we eat what we eat," as Prof Ganesh Bagler from IIIT-Delhi, puts it. The idea came about when he was teaching network science in IIT Jodhpur, and spoke to the students about the concept of a flavour network, that Yong-Yeol Ahn had studied, "of whether there are any general patterns that determine the ingredient combinations used in food today, or principles that transcend individual tastes and recipes," as the paper says.

To the scientist then, computational gastronomy is the study of ingredients, and how and why they are used with one another, where each ingredient "becomes a bowl of flavour molecules". It is looking at food as not just art, craft and skill, but also as a science. Which means the subject brings together data scientists and researchers, chefs, nutritionists, agriculturists, and people from the food industry, with the opportunity to bring about synergies. In terms of how far the science has developed, "We stand at 19th-century physics," he says. Some things will still be in the realm of art.

Prof Bagler specifically wants to look at Indian cuisine at the present, and understand food pairing, or the way in which ingredients are put together. The chief insight so far has been that while Indian food has contrasting food pairing (combining flavours that aren't similar to each other, in a dish), Western cuisine is based on complementary or uniform food pairing (flavours in a dish close to each other).

There are two initial legs to the process: recipe data compilation and ingredient (flavour) data compilation. It's not easy to identify 'set' recipes in India because every family may cook, say *dal*, in a different way, and through time the same recipe may have evolved to take into account modern practices. Prof Bagler started with Tarla Dalal's repertoire, but is happy to take in as many recipes, provided a person is making them regularly at home.

In terms of flavour molecules, data is compiled from the PubMed and Medline databases, which means research papers for 70-odd years are available. Information on ingredients has been extracted from these. There are about 1000 ingredients so far, with 192 unique ones, in the database. They will soon be compiling and publishing data on the health associations of ingredients.

Cognizant of both covert biases (like conflict of interest) and overt biases (like 'safe' studies added to the scientific body that are unlikely to rock the boat), Prof Bagler is trying to come up with strategies to discount for the bias. He is also conscious of reductionism and over-simplification of food practices, and says as the science grows, the complexity and layers of the subject will also grow. Take turmeric: we know it's good for health. But how much, in what quantity, in what way it was farmed, what ingredient bumps up its potential – all these are still to be studied. Going back to why we eat what we eat, Dr Bagler says that it could be a matter of taste, but it could also be because of the protective and sometimes medicinal value of our foods, but we need a deeper understanding of our food culture.

Byte-sized play-by-plays of tech concepts

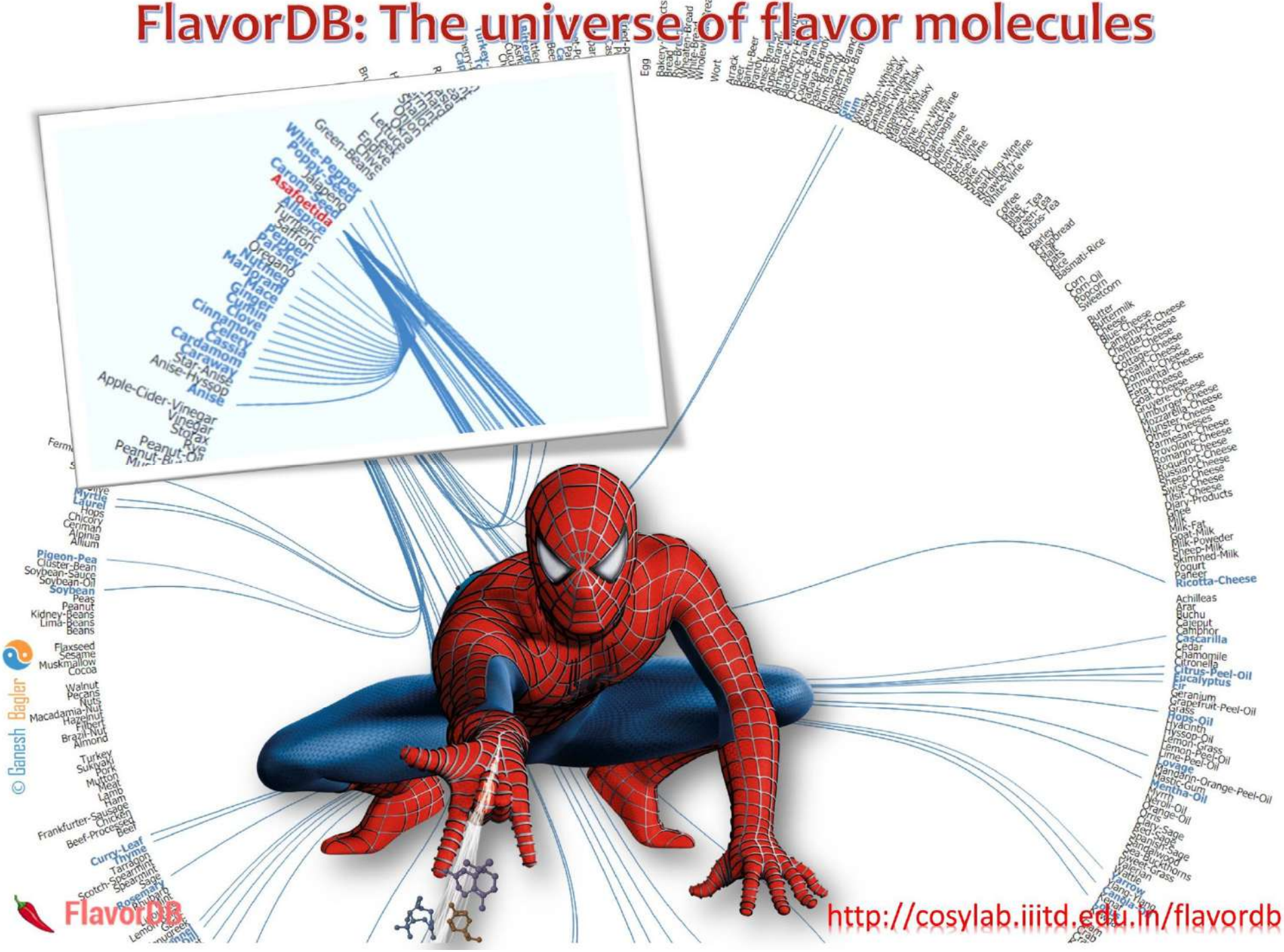
Data-driven investigations of culinary patterns in traditional recipes across the world

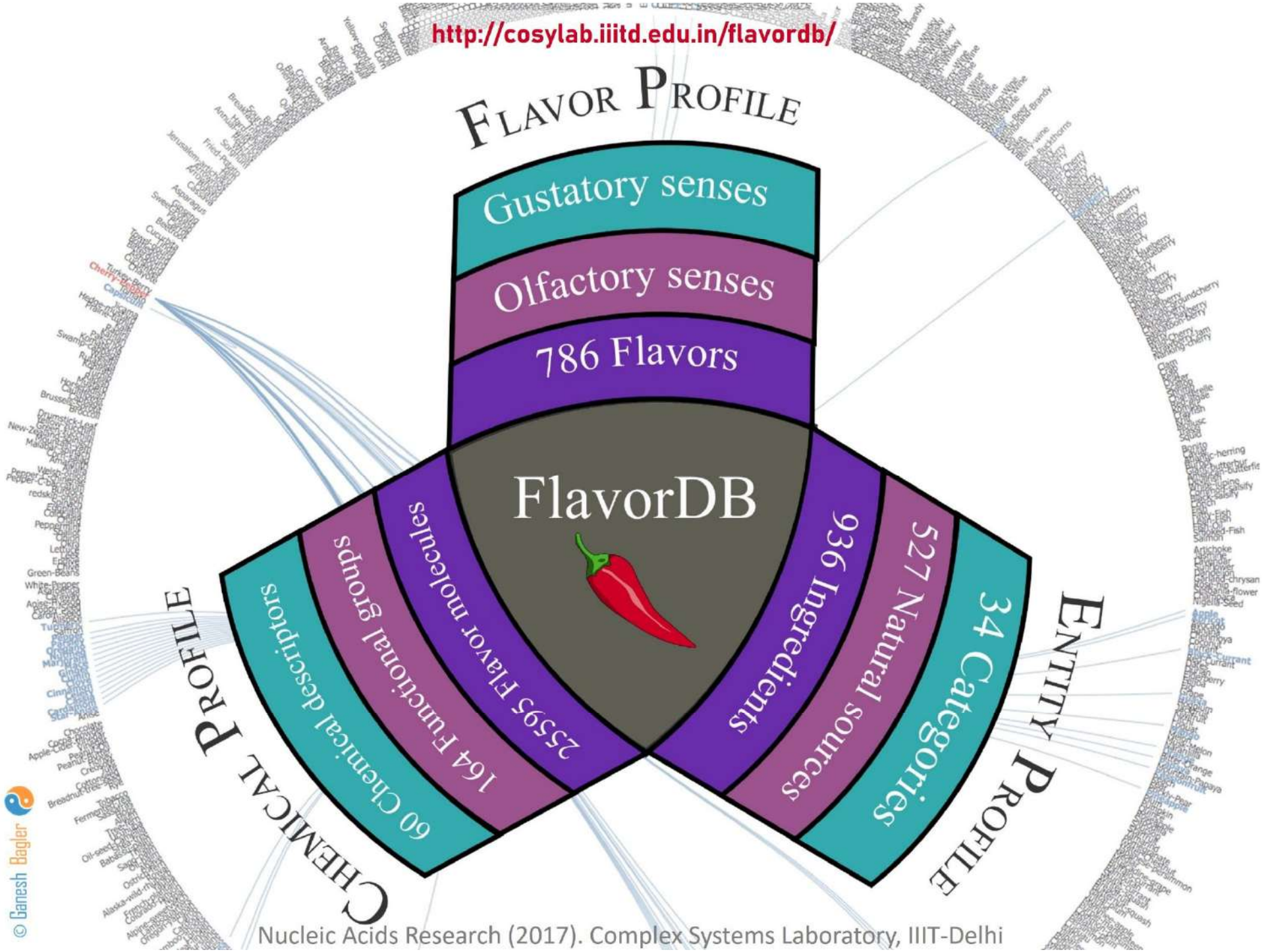
Navjot Singh and Ganesh Bagler* (2018), IEEE International Conference on Data Engineering, DÉCOR, Paris (2018).

The Ratatouille World

Credits: Wiki; Wired

FlavorDB: The universe of flavor molecules




http://cosylab.iiitd.edu.in/flavordb/
Flavor Profile
Gustatory senses
Olfactory senses
786 Flavors
FlavorDB
Chemical Profile
60 Chemical descriptors
164 Functional groups
25595 Flavor molecules
Entity Profile
936 Ingredients
527 Natural sources
34 Categories
© Ganesh Bagler
Nucleic Acids Research (2017). Complex Systems Laboratory, IIIT-Delhi

LAUNCHED@
World Heritage Cuisine Summit

FlavorDB

Trending Flavors

fruity	vanilla	mousy
balsamic	sweet	apple

Ingredient Categories


Dairy


Fruit


Fish


Herb

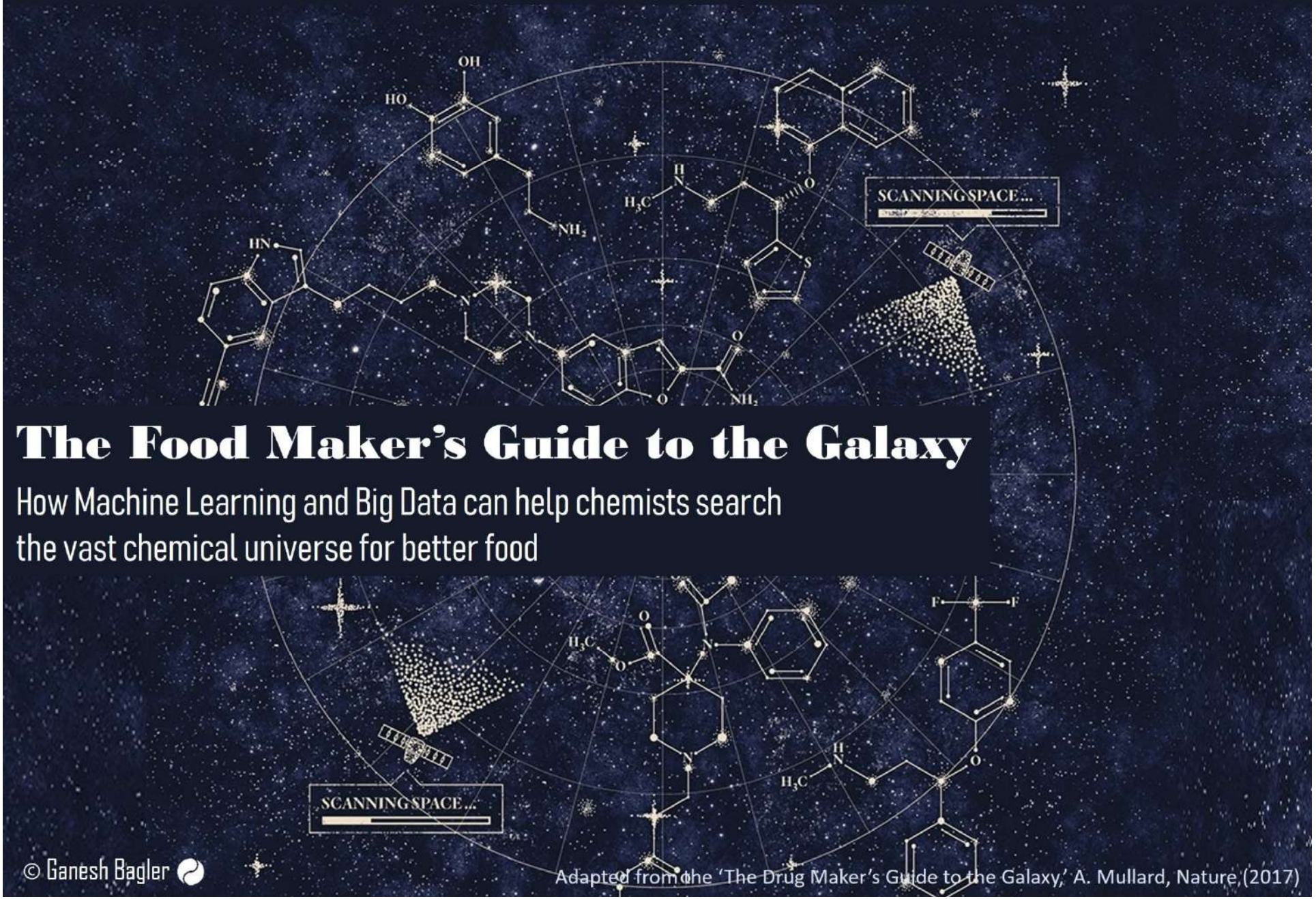

Meat


Bakery

VIEW ALL INGREDIENT CATEGORIES

Google Play

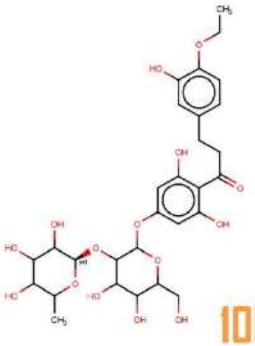
Computational Food



The Food Maker's Guide to the Galaxy

How Machine Learning and Big Data can help chemists search the vast chemical universe for better food

Adapted from the 'The Drug Maker's Guide to the Galaxy,' A. Mullard, Nature (2017)



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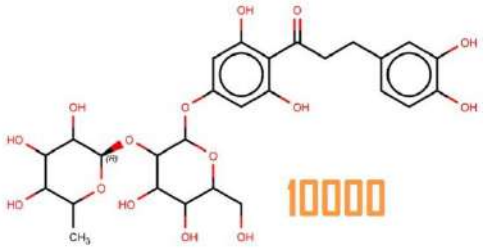

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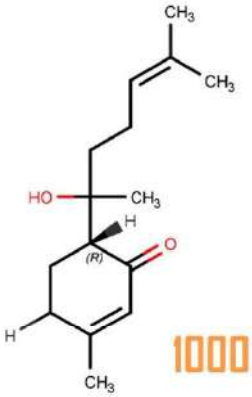

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Taste Classification & Prediction

1122018

Bitter — **Sweet**

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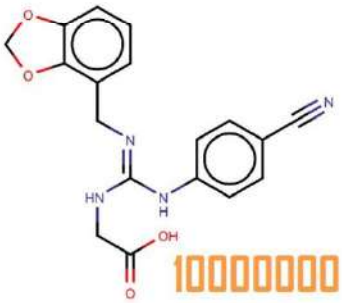

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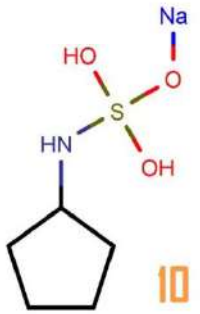
Sucrose, 1



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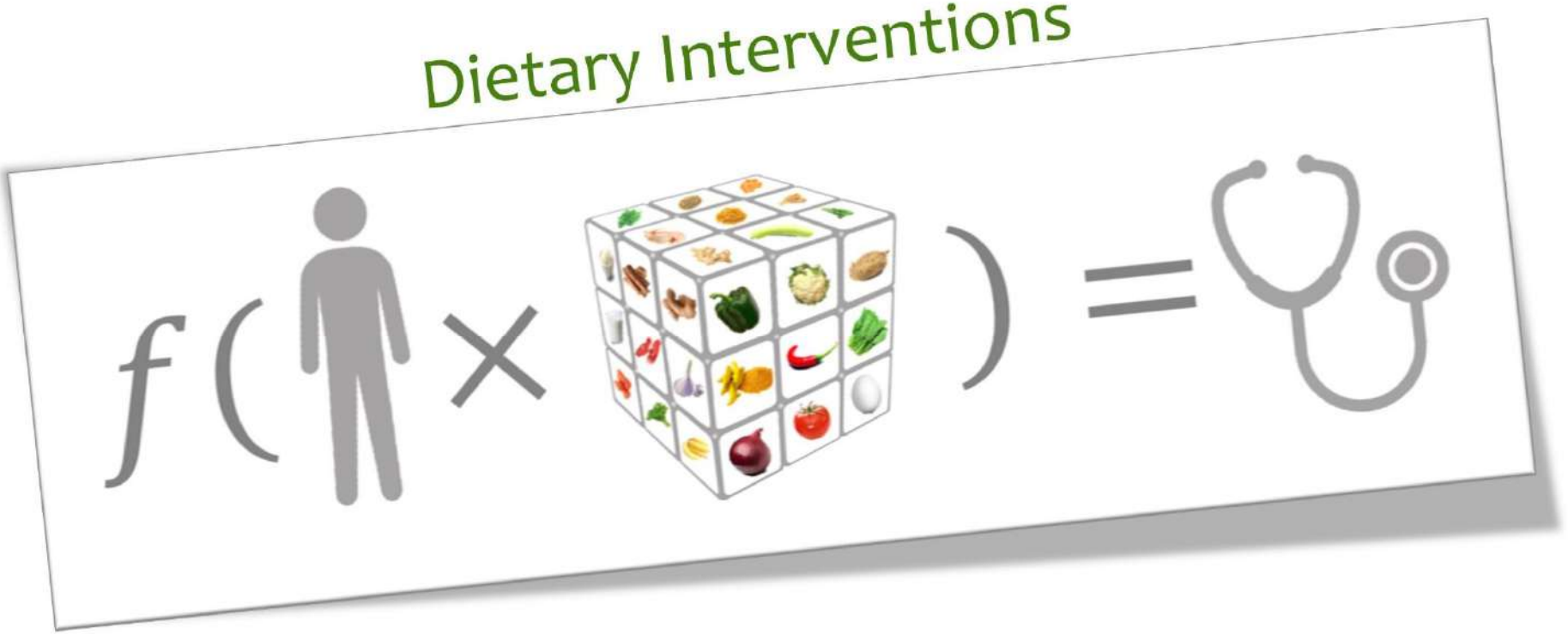
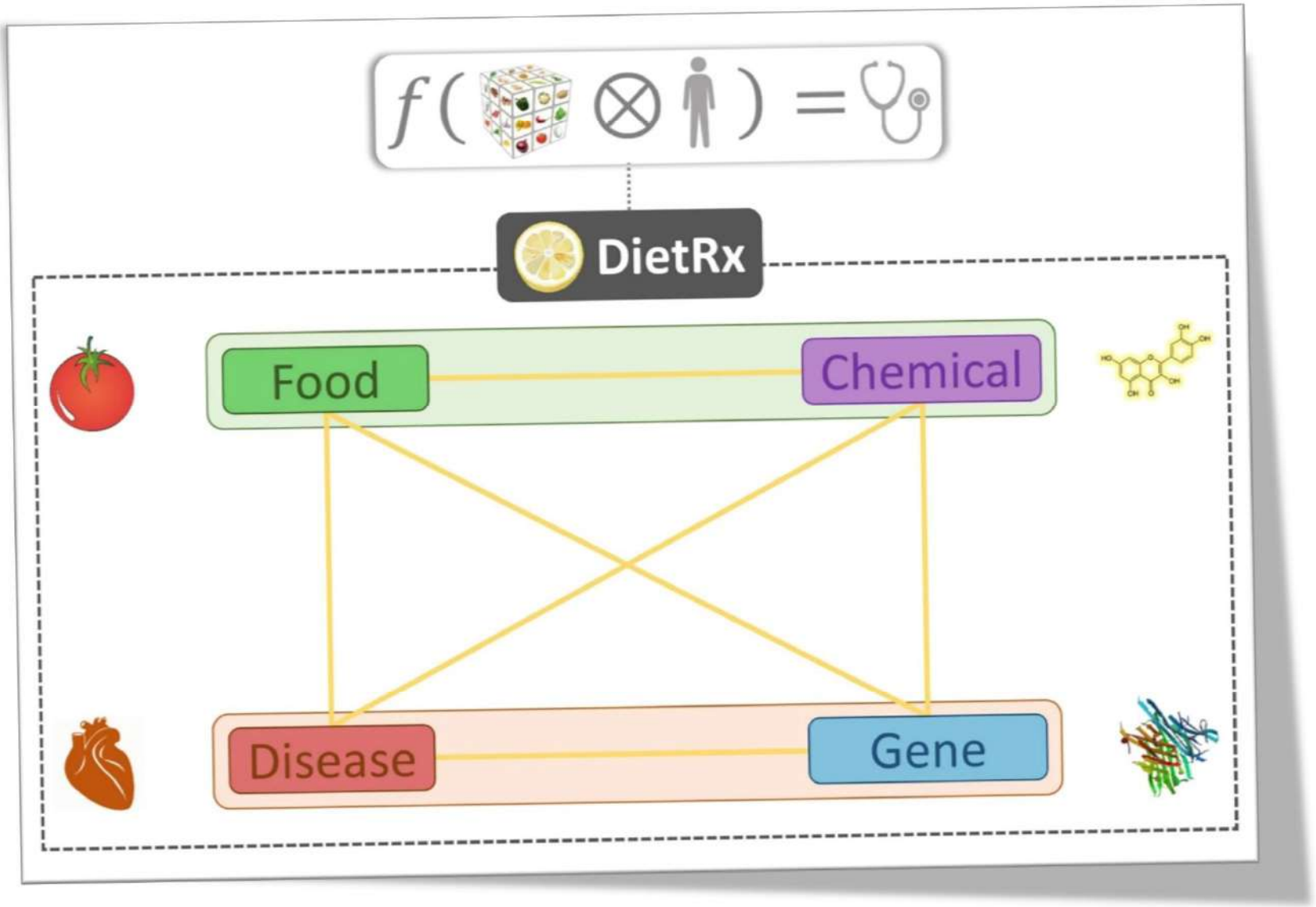
R Tuwani, S Wadhwa, and Ganesh Bagler*, 'BitterSweet: Building machine learning models for predicting the bitter and sweet taste of small molecules', Scientific Reports (2019). Accepted.

Dietary Interventions



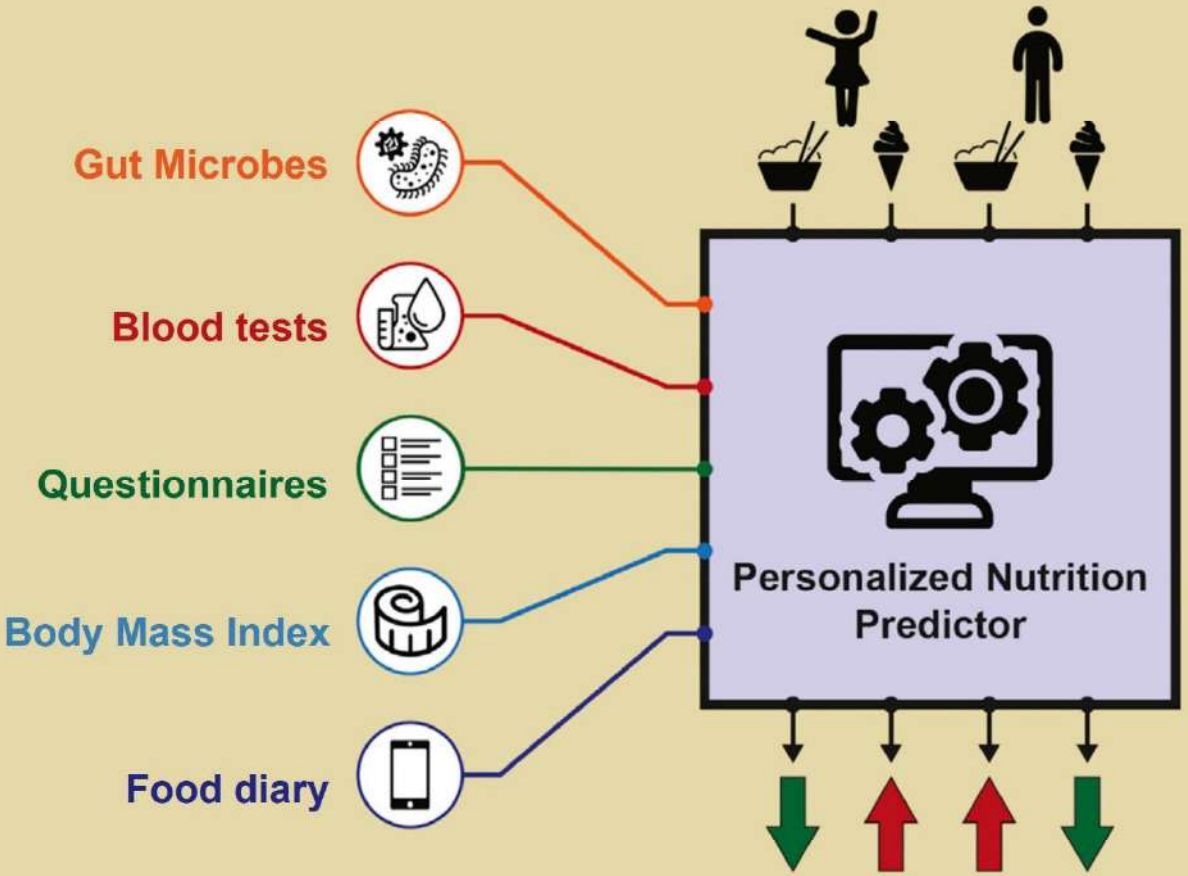
R Tuwani, Rakhi NK, N Garg and G Bagler*, Analytics-Under Review (2018); R Tuwani, Rakhi NK, and G Bagler*, Database-Under Review (2018).

DietRx: An integrated resource for health impact of food



R Tuwani, Rakhi NK, N Garg and G Bagler*, Analytics-Under Review (2018); R Tuwani, Rakhi NK, and G Bagler*, Database-Under Review (2018).

Personalized Nutrition



Design personalized diet to lower glucose levels

ED Sonnenburg and JL Sonnenburg, Nature, 528, 484 (2015).
Zeevi et al., "Personalized nutrition by prediction of glycemic response", Cell, 163, 1079 (2015).

Computational Gastronomy

- Food-Beverage Pairing
- Taste/Odor Prediction
- Culinary Fingerprinting
- Dietary Interventions
- Food & Beverages Design
- Sustainable Food Innovations

"The discovery of a new **dish** confers more happiness on humanity, than the discovery of a new **star**."

Jean Anthelme Brillat-Savarin

as seen in the canteen of Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, circa 1998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