NEWTRITION

To boldly go where no one has gone before...

The Buzz About Nutrient Deficiency:

Impacts of Pollinator Declines on Vitamin A Consumption

Yvonne Socolar
AFE 2018

The Birds and the Bees…

Peter Waters

The Birds and the Bees…

Pollinators in the World Food System

- 35% global food supply

US Forest Service

Many staple crops do NOT require pollinators:

- Grains (i.e. corn, wheat, rice)
  - Wind
- Potatoes, cassava, yam
  - Vegetative propagation (asexual reproduction)
- Soybeans, peas, sunflowers
  - Self-pollination

Frankel, R., and Galun, E. (2012). Pollination Mechanisms, Reproduction and Plant Breeding (Springer Science & Business Media).

Many staple crops do NOT require pollinators:

- Grains (i.e. corn, wheat, rice)
  - Wind
- Potatoes, cassava, yam
  - Vegetative propagation (asexual reproduction)
- Soybeans, peas, sunflowers
  - Self-pollination

Poor sources of most micronutrients!

Frankel, R., and Galun, E. (2012). Pollination Mechanisms, Reproduction and Plant Breeding (Springer Science & Business Media).

Pollinators’ Role in World Micronutrient Supply

- 40% world supply of some micronutrients

livescience.com

Smith, M.R., Singh, G.M., Mozaffarian, D., and Myers, S.S. (2015). Effects of decreases of animal pollinators on human nutrition and global health: a modelling analysis. The Lancet.

Pollinator Declines

- North America & Europe: managed honey bee colonies
- Non-managed pollinators
  - Diversity
  - Range

Sarah Scheub

Goulson, D., Nicholls, E., Botías, C., and Rotheray, E.L. (2015). Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. Science.

Pollinator Declines

- North America & Europe: managed honey bee colonies
- Non-managed pollinators
  - Diversity
  - Range

- Why?
  - Pests
  - Pesticides
  - Disease
  - Habitat loss

Sarah Scheub

Goulson, D., Nicholls, E., Botías, C., and Rotheray, E.L. (2015). Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. Science.

Modelling Impacts of Declines

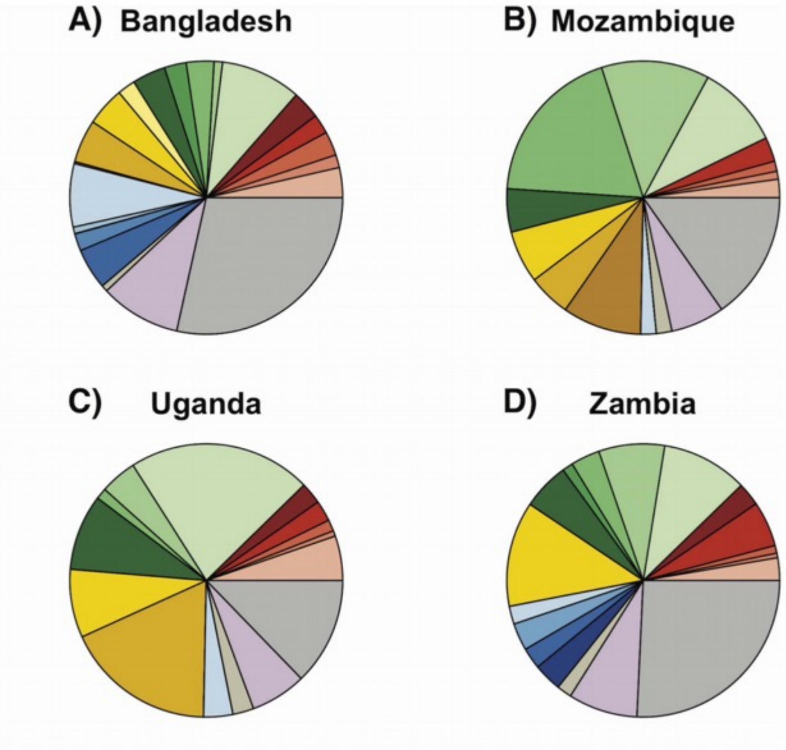
- Ellis et al., 2015
  - Modelling analysis of Bangladesh, Mozambique, Uganda, Zambia
  - Complete die-off scenario

- Smith et al., 2015
  - Modelling analysis of 156 countries
  - Complete die-off, as well as 50% and 75%

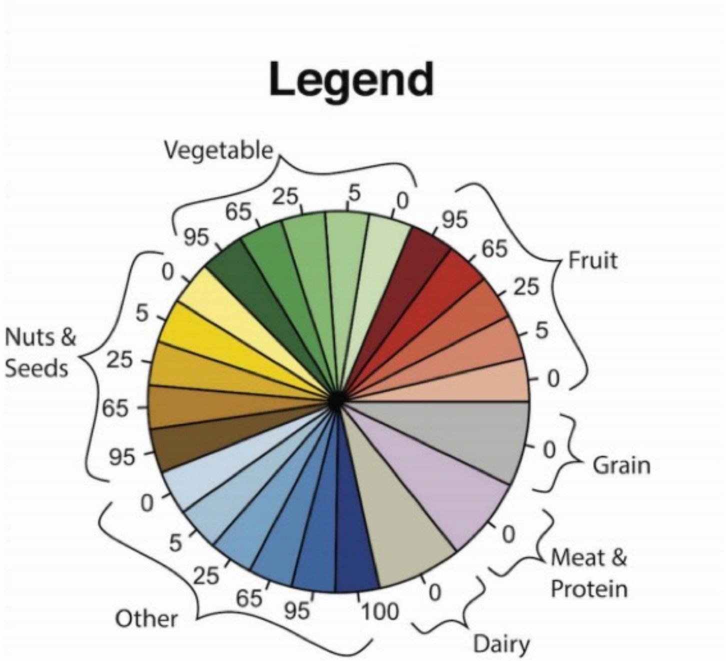
Ellis, A.M., Myers, S.S., and Ricketts, T.H. (2015). Do Pollinators Contribute to Nutritional Health? PLOS ONE.
Smith, M.R., Singh, G.M., Mozaffarian, D., and Myers, S.S. (2015). Effects of decreases of animal pollinators on human nutrition and global health: a modelling analysis. The Lancet.

Which micronutrients will be most affected?

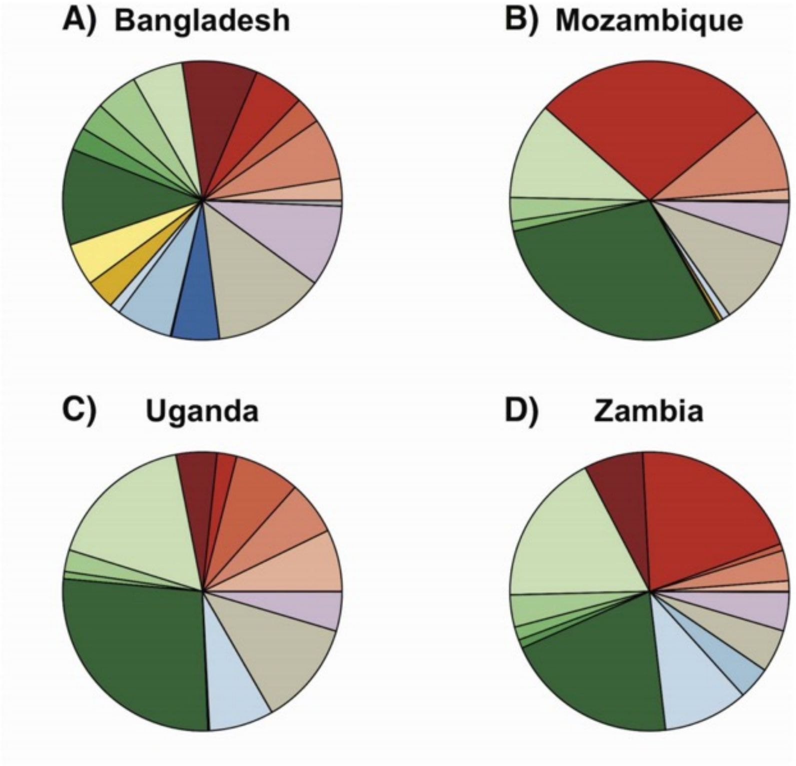
- Zinc?
- Iron?
- Calcium?
- Folate?
- Vitamin A?



Iron



Vitamin A



Ellis et al., 2015

Pollinator Impacts on Vitamin A

- Ellis et al., 2015
  - Uganda & Mozambique
  - NEWLY deficient children increase 15-56%

- Smith et al., 2015
  - Newly deficient: 71 million (41-262 mil, 95% uncertainty interval)
  - Further declines: 2.2 billion (1.2-2.5 bil, 95% UI)

Vitamin A

- Immune function
- Reproduction
- Cell communication
- Vision

Pollinator contributions: sweeter than honey

Matt Allan
AFE 2017
NewTrition

Blessed in Abundance

The Role of Irrigated Agriculture in the 19th Century Mormon Faith

Agrarian Roots of the Mormon Faith

- While translating the Book of Mormon, Joseph Smith stayed at the Whitner farm in Fayette, NY (1830)
- From New York, the early Mormon people fled to Ohio and Missouri, and then to Illinois before making their trek to what is now Utah.

Pueblo Predecessors

- Before colonial settlement in the Americas, a number of tribes practiced irrigation to varying degrees
    - Hohokam
    - Mogollon
    - Anasazi (Ancestral Puebloans)
    - Patayan

City Creek Diversion

- In July 1847, a group of Mormon settlers dammed City Creek and cut ditches to irrigate a potato field in the advance of Brigham Young’s arrival.
  - Their settlement would be known as Salt Lake City.
- The Mormons soon expanded out from Salt Lake City into the greater Wasatch Oasis.
  - Cooperative labor operations

Expansion of Mormon Irrigation

- A “thoroughly disciplined hierarchy” may have facilitated the otherwise arduous task of implementing an irrigation system.
- By 1849, the Mormon people were harvesting approximately 17,000 acres.

Mormon Women in the Frontier

- While the act of cutting irrigation ditches may, like many projects along the American frontier, evoke images of masculinity, Mormon women were active agents in daily life and community decisions.

Implications & Limitations

- Because the Mormon people have been little-studied by non-Mormons, the academic literature can border on hagiography.
- Climate change is anticipated to increase drought risk and severity in the American Great Plains and Southwest (Cook, Ault, and Smerdon, 2015).
- Combatting and adapting to climate change will require the exercise of political and ecological imagination.

Acknowledgements

- This presentation could not have happened without the invaluable help of the following individuals:
  - Jessie Ellis
  - Katherine Rancano
  - Kenny Westerman
- I would also like to thank the Friedman School administration as well as the Student Council for their support of the NewTrition program.

References

Alexander, Thomas G. “Irrigating the Mormon Heartland: The Operation of the Irrigation Companies in Wasatch Oasis Communities, 1847-1880.” *Agricultural History* 76, no. 2 (2002): 172–87.

Arrington, Leonard J. “Rural Life among Nineteenth-Century Mormons: The Woman’s Experience.” *Agricultural History* 58, no. 3 (July 1984): 239–46.

Arrington, Leonard J., and Dean May. “‘A Different Mode of Life’: Irrigation and Society in Nineteenth-Century Utah.” *Agricultural History* 49, no. 1 (January 1975): 3–20.

Cook, Benjamin I., Toby R. Ault, and Jason E. Smerdon. “Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains.” *Science Advances* 1, no. 1 (February 2015).

Frase, Peter. “Four Futures.” *Jacobin* 5 (December 2011): 27-34.

Hess, Ralph H. “The Beginnings of Irrigation in the United States.” *Journal of Political Economy* 20, no. 8 (October 1912): 807–33.

Hodge, F. W. “Prehistoric Irrigation in Arizona.” *American Anthropologist* 6, no. 3 (July 1893): 323–30.

Culturing Food

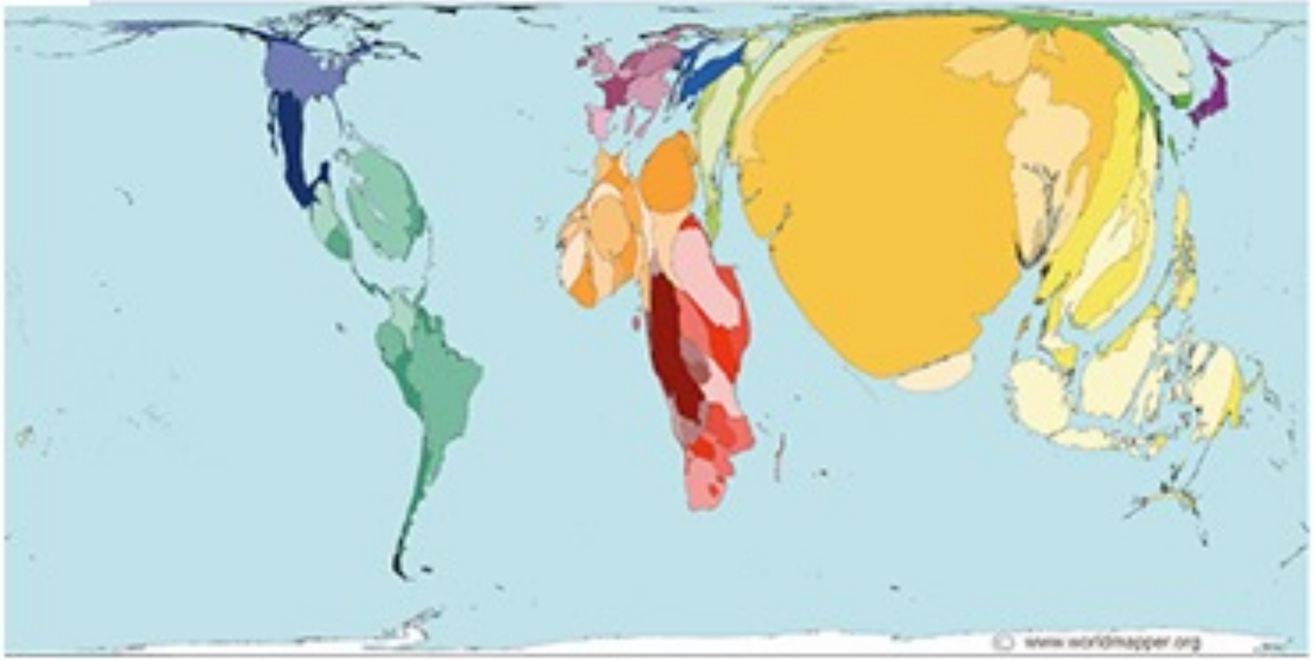
Iron Absorption in a Changing Climate

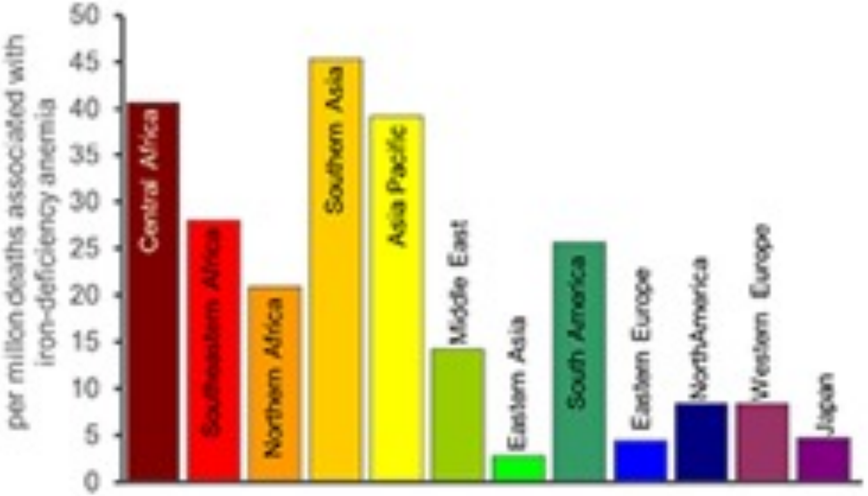
Julie Kurtz

MS Candidate| Agriculture, Food & Environment

Risk Areas for Iron Deficiency

- 2.75 billion people depend on crops that will suffer iron loss as CO_2 increases
- 2050 Projection: 1.4 billion (60% of population in vulnerable areas) will suffer significant iron decrease (>3.8%)





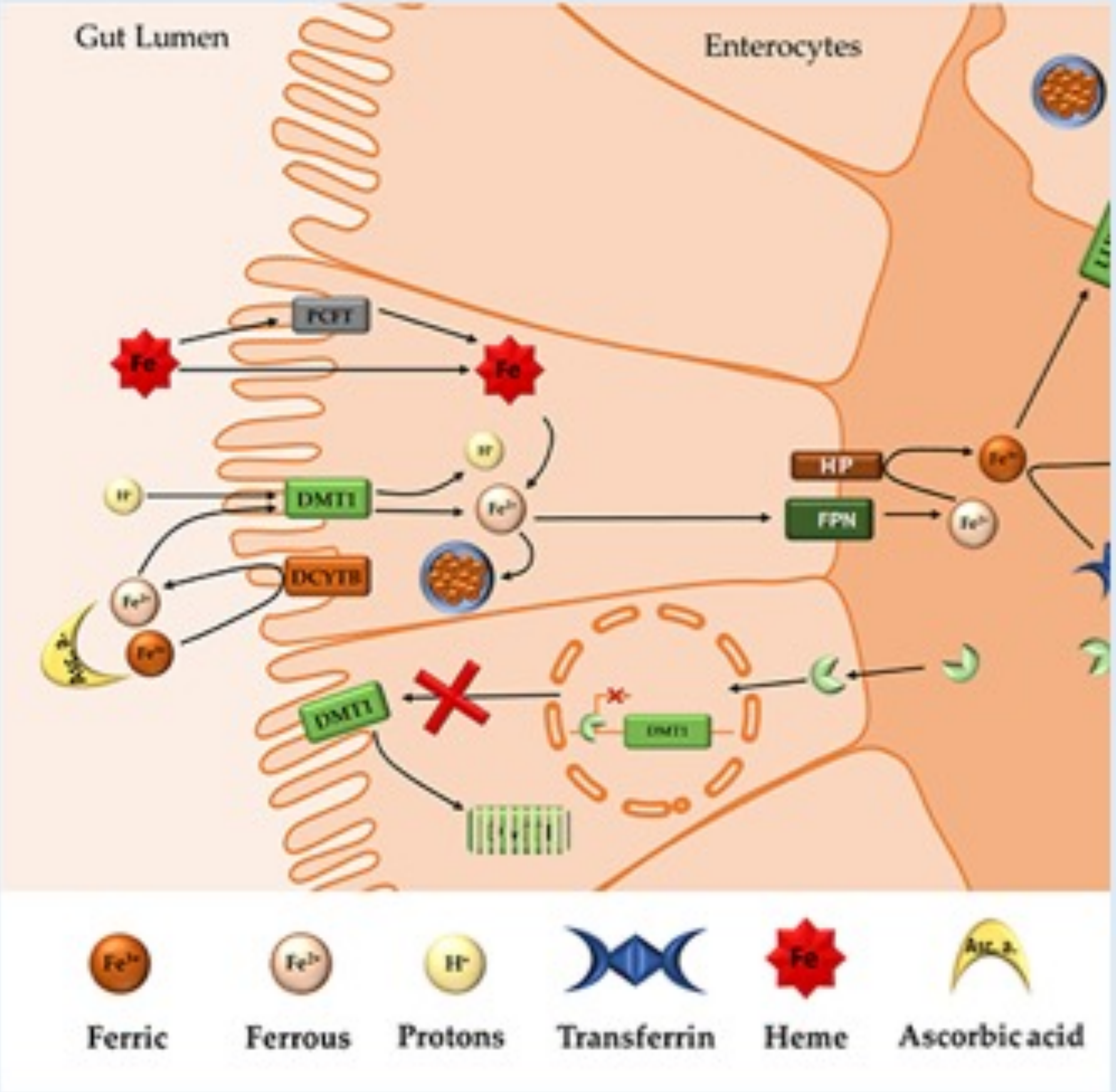
Source: Maria Augusta Naranjo-Arcos and Petra Bauer (2016). Iron Nutrition, Oxidative Stress, and Pathogen Defense, Nutritional Deficiency,

Iron,
It's What's for Dinner

http://ods.od.nih.gov/factsheets/Iron-HealthProfessional/

Food	Iron mg/serving	Percent DV*
Breakfast cereals, fortified with 100% of the DV for iron, 1 serving	18	100
Oysters, eastern, cooked with moist heat, 3 ounces	8	44
White beans, canned, 1 cup	8	44
Chocolate, dark, 45%–69% cacao solids, 3 ounces	7	39
Beef liver, pan fried, 3 ounces	5	28
Lentils, boiled and drained, ½ cup	3	17
Spinach, boiled and drained, ½ cup	3	17
Tofu, firm, ½ cup	3	17
Kidney beans or chickpeas canned, ½ cup	2	11
Sardines, Atlantic, canned in oil, drained solids with bone, 3 ounces	2	11
Tomatoes, canned, stewed, ½ cup	2	11
Beef, braised bottom round, trimmed to 1/8" fat, 3 ounces	2	11
Potato, baked, flesh and skin, 1 medium potato	2	11
Cashew nuts, oil roasted, 1 ounce (18 nuts)	2	11
Green peas, boiled, ½ cup	1	6
Chicken, roasted, meat and skin, 3 ounces	1	6
Raisins, seedless, ¼ cup	1	6
Tuna, bluefin, fresh, cooked with dry heat, 3	1	6

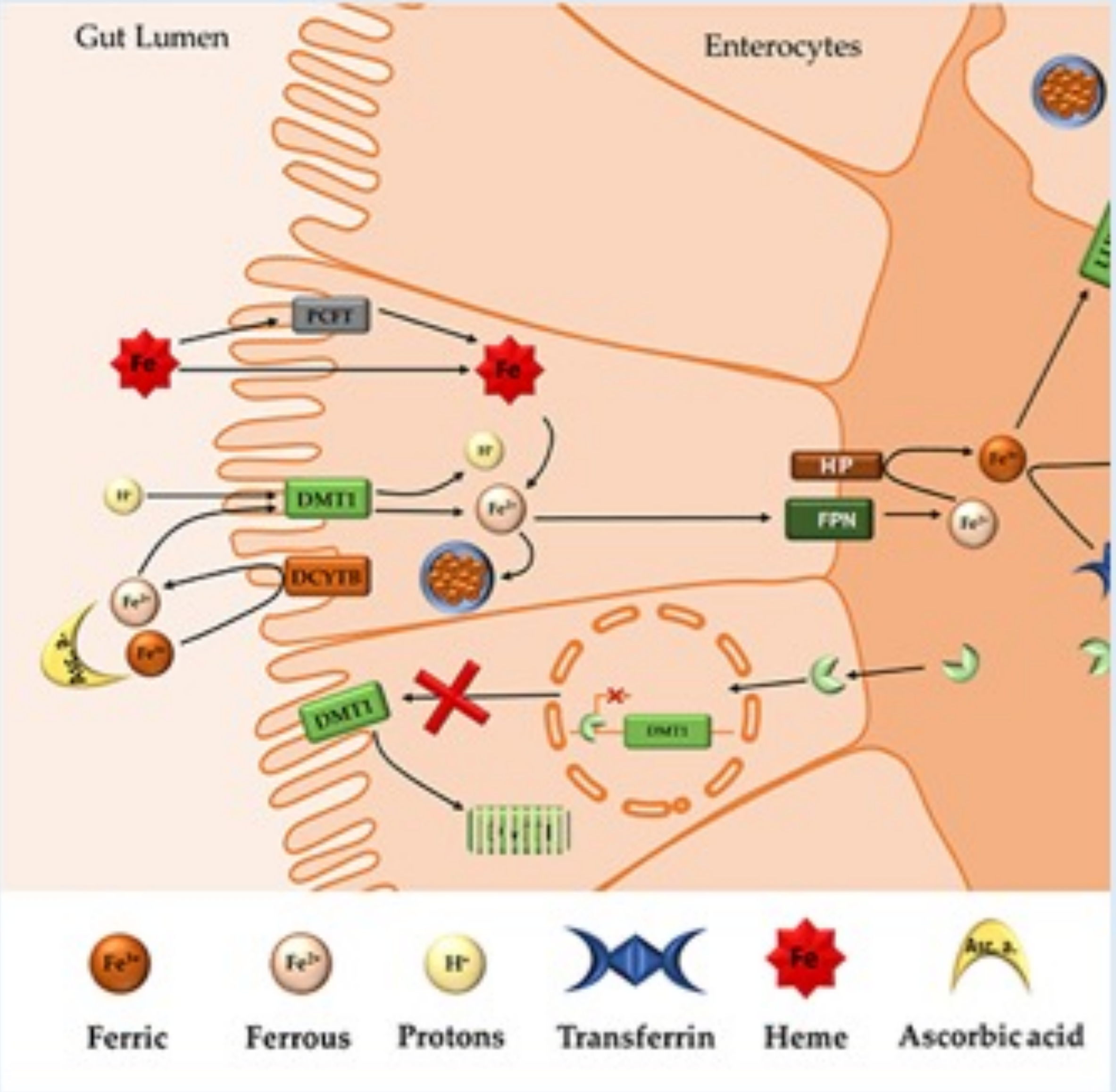
Iron: A Problem of Bioavailability



- Heme iron (from animal sources): 15-25% bioavailable
- Non-heme iron (from plant sources): 5-12% bioavailable
- Mixed Diets: 14-18% bioavailable

Source: Maria Augusta Naranjo-Arcos and Petra Bauer (2016)

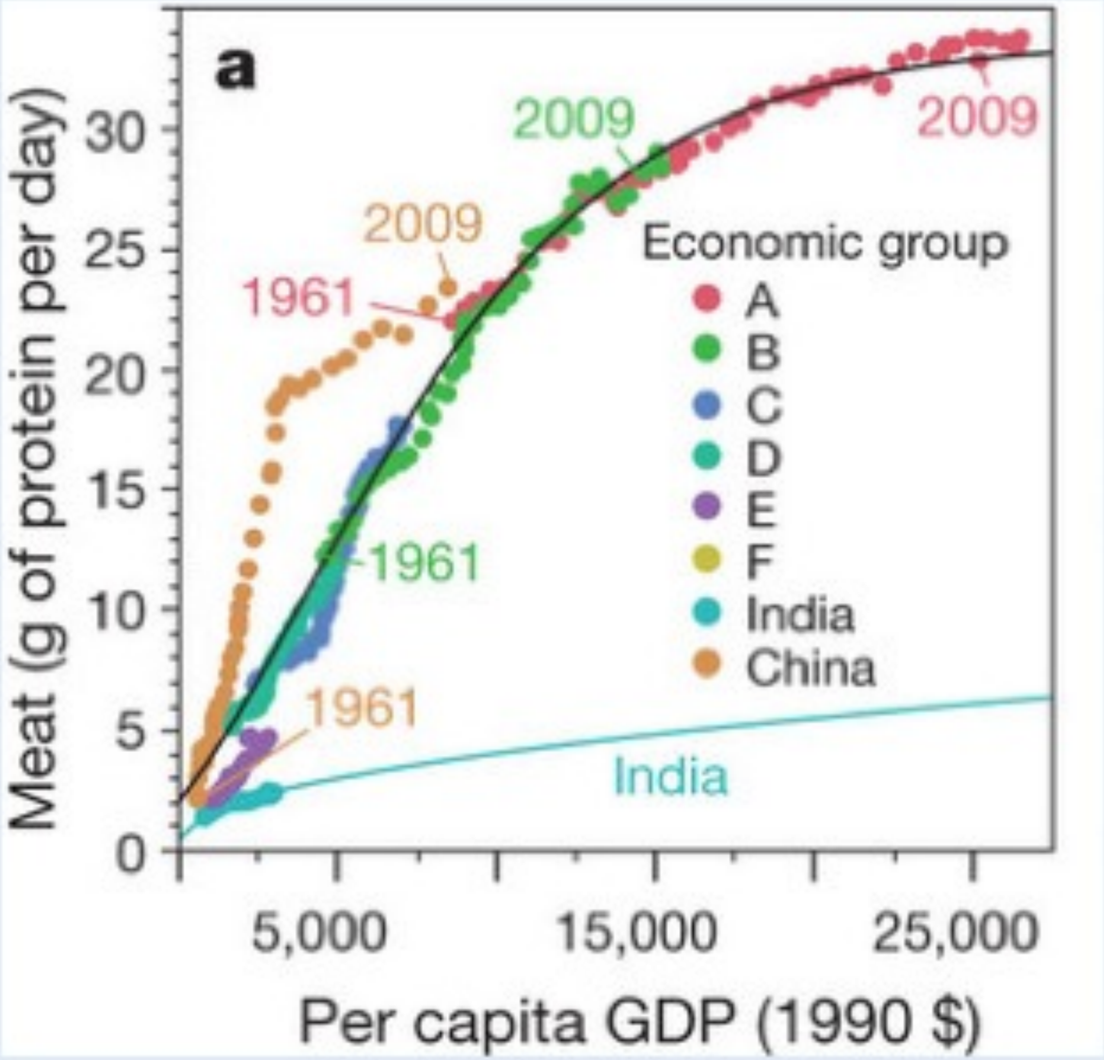
Iron: A Problem of Bioavailability



- Heme iron (from animal sources): 15-25% bioavailable
- Non-heme iron (from plant sources): 5-12% bioavailable
- Mixed Diets: 14-18% bioavailable
- Absorption factors:
  - Inhibitors or enhancers
  - Gut lumen factors (e.g. pH)
  - Solubility of iron

Source: Maria Augusta Naranjo-Arcos and Petra Bauer (2016)

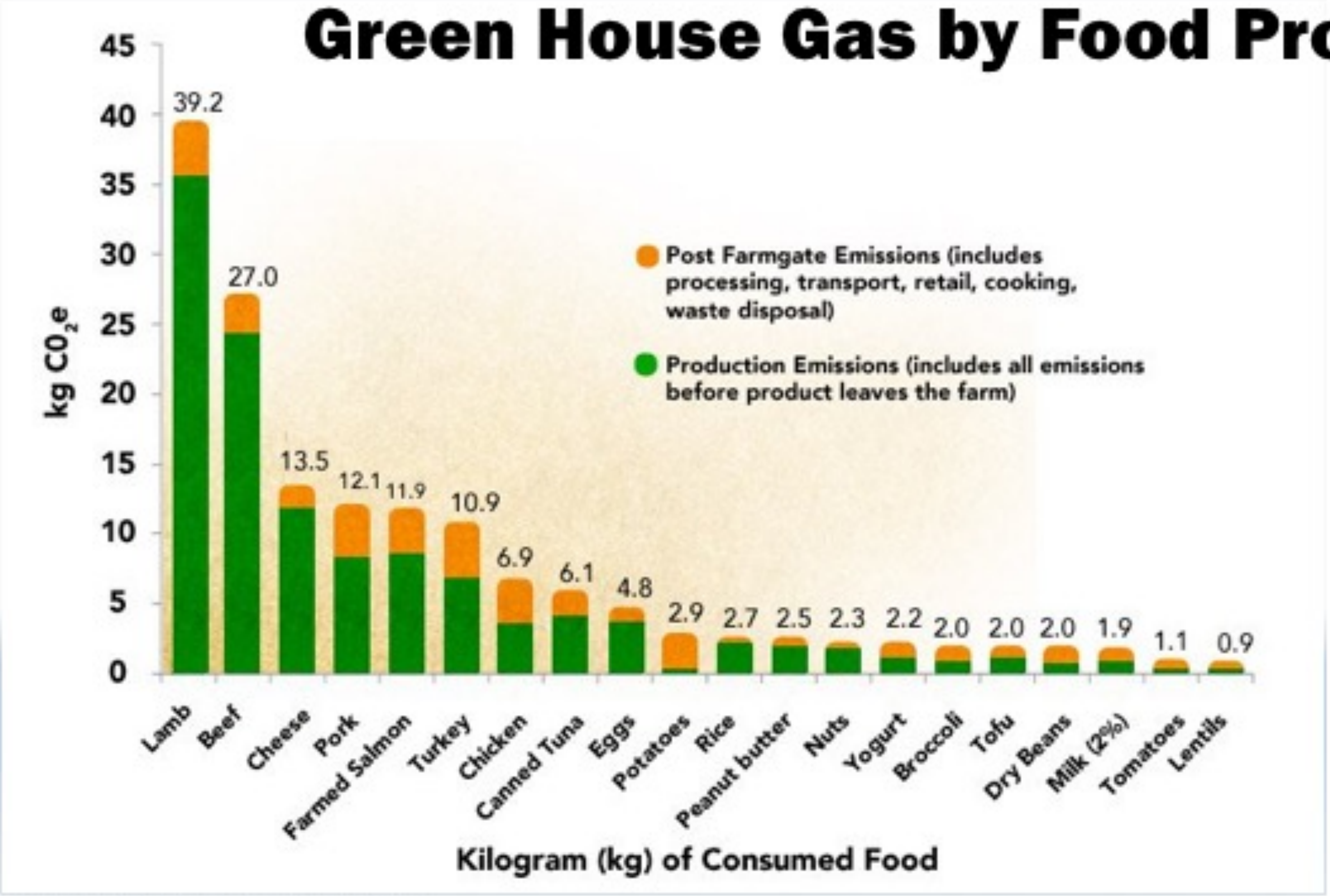
Meat Consumption is on the Rise



Per capita daily dietary demand for meat

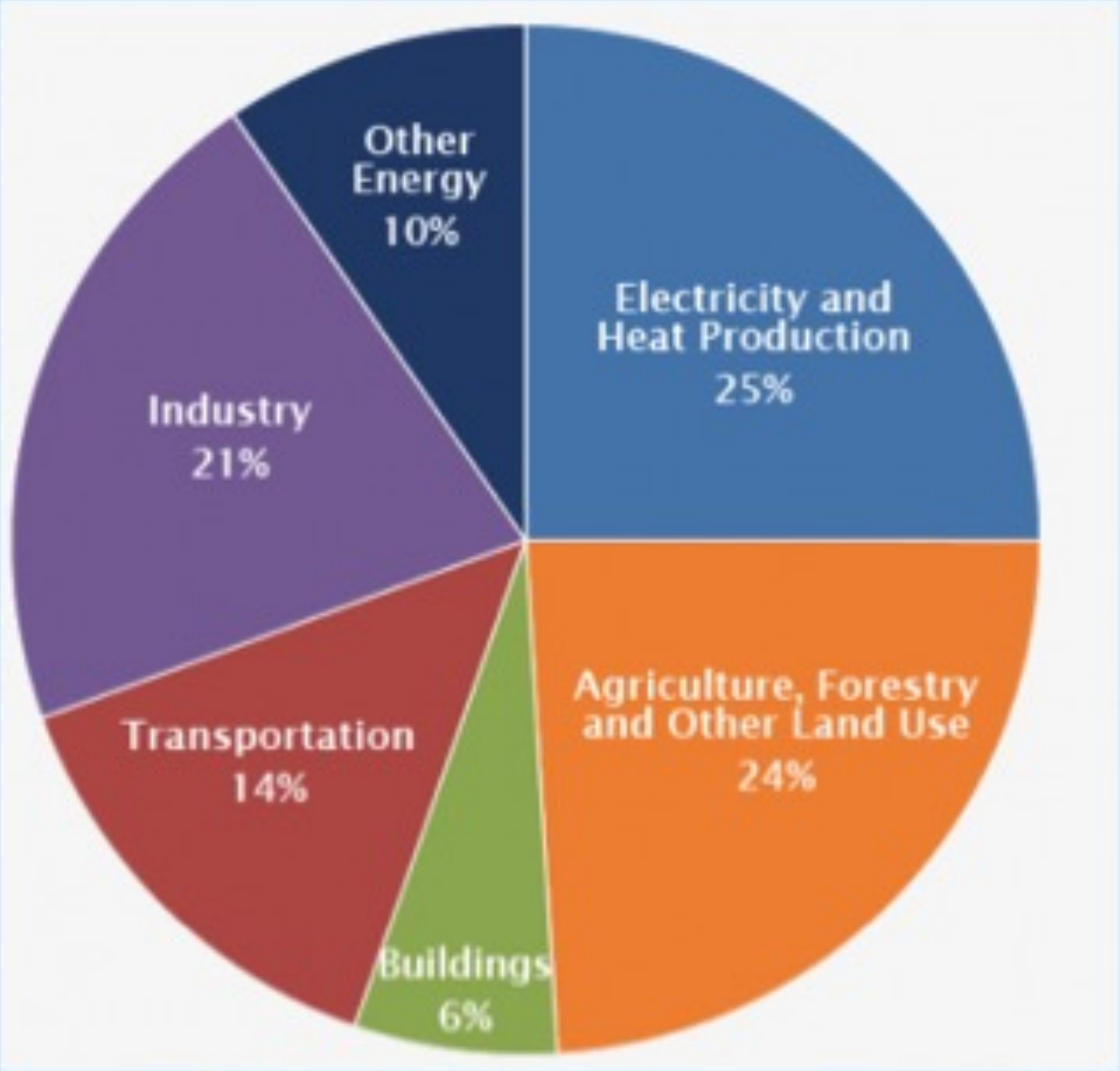
Source: Tilman, David, and Michael Clark. "Global diets link environmental sustainability and human health." *Nature* 515.7528 (2014): 518-522.

Green House Gas by Food Product



Source: Environmental Working Group, 2011.

Anthropogenic Green House Gas Contributors

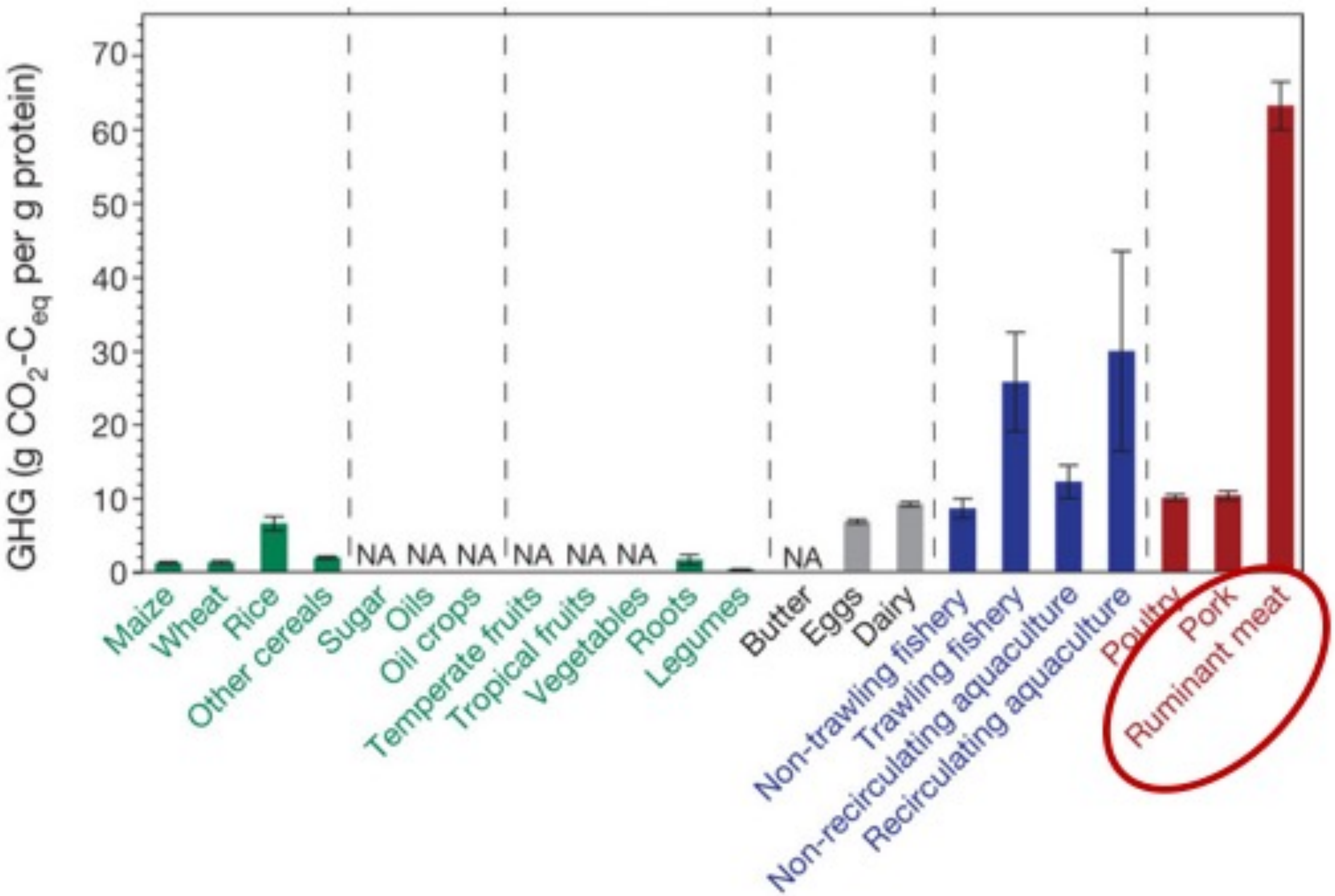


Source: IPCC 2014. Climate Change 2014: Mitigation of Climate Change.

GHG emissions in terms of CO2-eq.

Forestry includes deforestation.

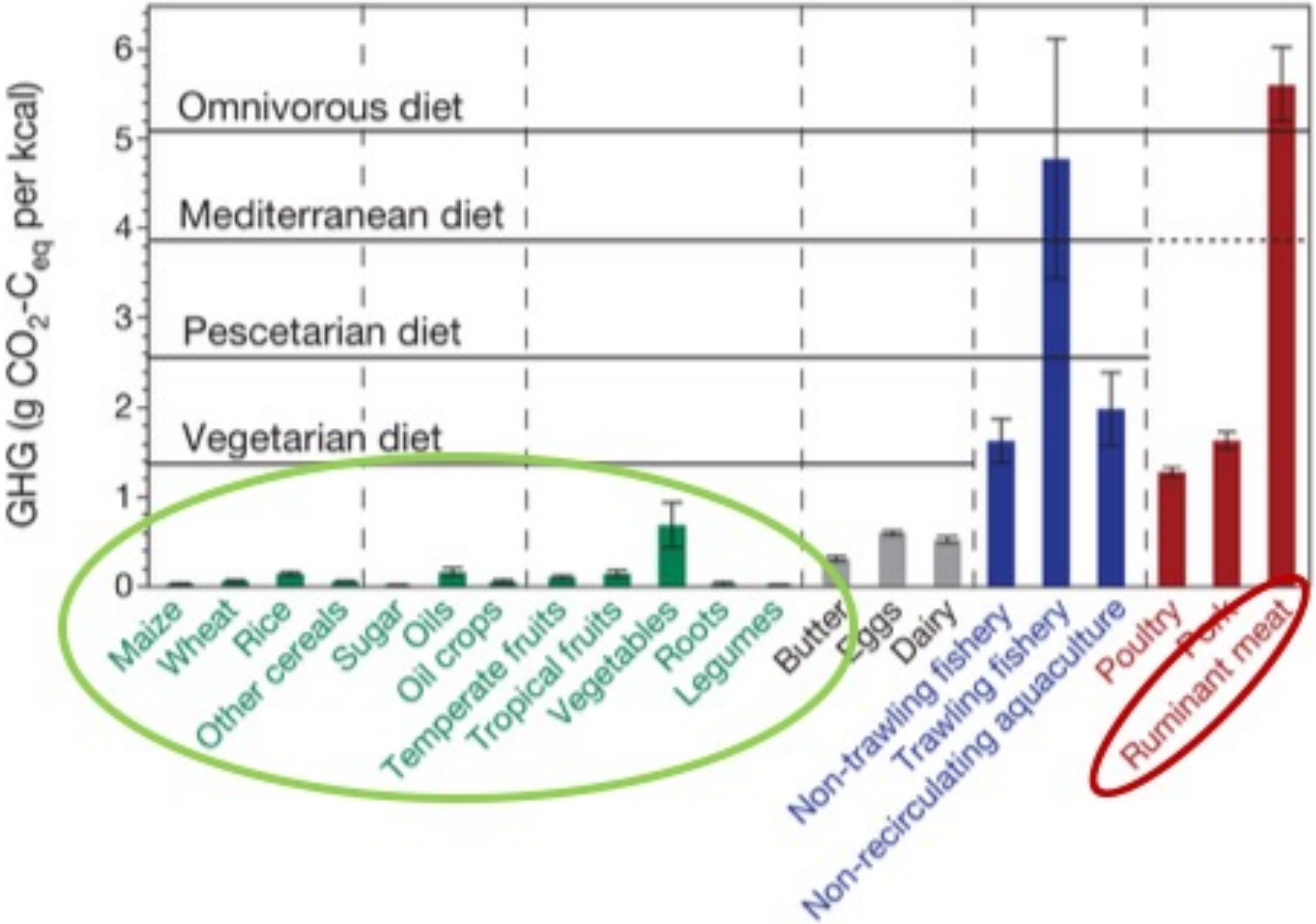
Per kg cradle to farm gate climate impact



(Tilman, Clark 2014)

Per kcal cradle to farm gate climate impact

Animal-based foods cannot sustainably solve iron deficiency



(Tilman, Clark 2014)

Iron Absorption from Meals with Fresh and Fermented Vegetables

Meal	n	Non-heme iron content mg/serving (240 g)	Absorption %		Individual absorption[d] A40 %		Mean of individual absorption ratio F:C[e]	Myo-inositol hexaphosphate µmol/serving (mg phytate-P)
			Meal	Ref. dose	Mean	SEM		
Low-phytate meal								
White wheat rolls[a,f] + fresh vegetables[b]	8	4.4	9.5	25.0	13.6±	1.6	1.78 ± 0.10	6.1 (1.1)
White wheat rolls[a,f] + fermented vegetables[b,f]	8	4.4	15.6	25.0	23.6±	2.0		2.5 (0.5)
High-phytate meal								
Wheat bran rolls[c,f] + fresh vegetables[b,f]	9	4.0	4.6	36.8	5.2±	0.8	2.07 ± 0.16	159.2 (29.6)
Wheat bran rolls[c,f] + fermented vegetables[b,f]	9	4.0	8.8	35.8	10.4±	2.4		155.6 (28.9)

[a] 140 g white wheat rolls

[b] 100 g fresh or fermented vegetables

[c] 140 g wheat bran rolls

[d] Mean individual absorption ratios (test meal/reference dose) were multiplied by 40 to obtain the percentage absorption of iron corresponding to a 40 % reference dose absorption

[e] C = meal with fresh vegetables; F = meal with fermented vegetables

[f] All analytical measurements were taken in duplicates

Scheers, Nathalie, et al. "Increased iron bioavailability from lactic-fermented vegetables is likely an effect of promoting the formation of ferric iron (Fe^{3+})." *European journal of nutrition* 55.1 (2016): 373-382.

Heme and Non-heme Iron Digested In Vitro

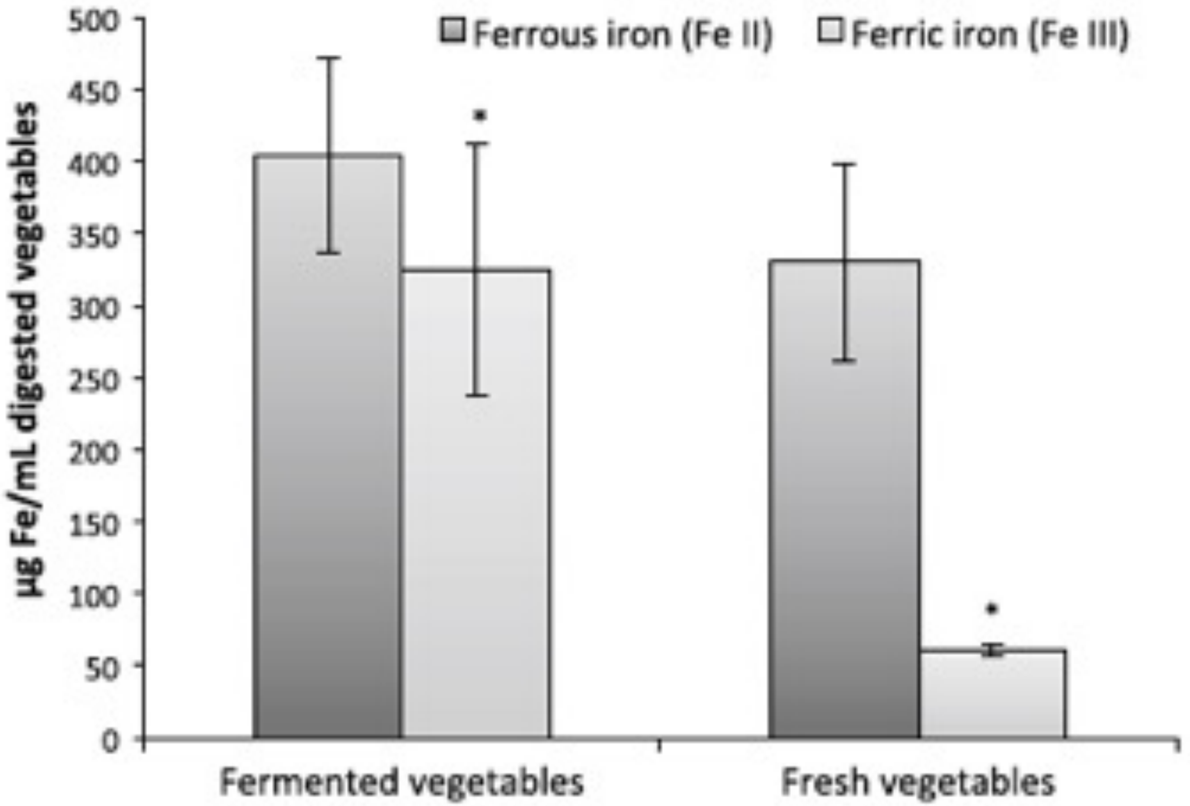


Fig. 2 Differential pulse anodic stripping voltammetry measurements of Fe^{2+} and Fe^{3+} species in in vitro digested fermented and fresh vegetables. Data are presented as mean ± SD ($n = 15$). An *asterisk* indicates a significant difference ($p < 0.05$)

Scheers et al (2016)

Mechanisms of Increased Iron Absorption due to Fermentation

- Phytate inhibitors mitigated by phytases
- Increased Soluble Iron
- Lower pH improves reduction of Fe^{3+}
- Increased Lactic Acid → Chelates Iron, which prevents it binding with phytates
- Delayed gastric emptying rate → increases exposure to intestinal epithelium

Concluding Questions

- Have we overlooked culinary preparation as one of the key vehicles for aiding nutrition intake?
- Can we look to meat for daily iron source in the context of a heating climate?

Thank you for attending!

For more information, to join the team, or if you'd like to speak at a future event please contact:

- Kenny Westerman (Kenneth.Westerman@tufts.edu)
- Katherine Rancano (Katherine.Rancano@tufts.edu)
- Jessie Ellis (Jessica.Ellis@tufts.edu)

NewTrition: A discussion of new ideas and thoughts in nutrition and health through TED Talk-style conversations

Food In the Age Of (Big) Data

A 'NewTrition' Talk

Martin Obin, PhD

Friedman School of Nutrition Science and Policy, Tufts University, Boston MA

October 26, 2016

This, H. *EMBO Rep*. 2006 Nov; 7(11): 1062–1066.

Take-Home:

Data-driven analysis methods that have transformed biology and social sciences can yield new insights into food science writ large.

Computational / Synthetic Gastronomy (Sebastian Ahnert, 2013)

"Gastronomy - the knowledge of whatever concerns man's nourishment."

This, Herve. EMBO Rep. 2006 Nov; 7(11): 1062–1066.

A Working Definition of Computational Gastronomy:

A multidisciplinary field in which computational techniques are applied to gastronomy data to identify new ways to source food sustainably, new sources of edible ingredients, and to understand the chemosensory, nutritional, cultural, anthropological and psychological determinants of food choice.

Distinguished from "Molecular Gastronomy," which is focused primarily on the chemistry and physics behind the preparation of any dish (e.g., why mayonnaise becomes firm or why a soufflé swells), and which has led to a new *haute* cuisine for which people are prepared to spend a small fortune.

Ahnert *Flavour* 2013, **2**:4
http://www.flavourjournal.com/content/2/1/4

OPINION **Open Access**

Network analysis and data mining in food science: the emergence of computational gastronomy

Sebastian E Ahnert

Abstract

The rapidly growing body of publicly available data on food chemistry and food usage can be analysed using data mining and network analysis methods. Here we discuss how these approaches can yield new insights both into the sensory perception of food and the anthropology of culinary practice. We also show that this development is part of a larger trend. Over the past two decades large-scale data analysis has revolutionized the biological sciences, which have experienced an explosion of experimental data as a result of the advent of high-throughput technology. Large datasets are also changing research methodologies in the social sciences due to the data generated by mobile communication technology and online social networks. Even the arts and humanities are seeing the establishment of 'digital humanities' research centres in order to cope with the increasing digitization of literary and historical sources. We argue that food science is likely to be one of the next beneficiaries of large-scale data analysis, perhaps resulting in fields such as 'computational gastronomy'.

Keywords: Networks, Data mining, Sensory science, Computational gastronomy, Flavour compounds

Computational Gastronomy - Food in the Age of Data

Workshop Date

September 29th (Monday) and **30th** (Tuesday), 2014

Venue

Kavli Royal Society International Centre
Chicheley Hall, Chicheley
Newport Pagnell
Buckinghamshire MK 16 9JJ
+44 (0) 1234 868 650

FOOD AND DATA WORKSHOP: INTEROPERABILITY THROUGH THE FOOD PIPELINE

12-13 September, 2016 : University of Illinois at Urbana-Champaign

CSL: Coordinated Science Lab
University of Illinois at Urbana-Champaign

search

Agenda

Computational Gastronomy Employs ‘Standard’ Big Data Approaches and Methods

- crowdsourcing,
- data curation and mining,
- large-scale data analysis,
- machine learning,
- network analysis

Data Sources for Computational Gastronomy

- Databases of food preferences, food preparation and food consumption
- Online recipes
- Databases of chemical compounds in foods
- Restaurant reviews
- Cultural, social-economic data
- Omics' data

How can the new abundance of data and computational power help us investigate the way we eat food ?

How might the availability of these data shape our culinary habits and preferences?

An example: Are there quantifiable principles underlying our choice of certain ingredient combinations (recipes) and avoidance of others?

Suggested by the observation that we use only a small fraction of the possible ingredient combinations.

- Relatively small number of recipes in use (~ 10^6) compared to number of potential recipes ($>10^{15}$).
- Frequent recurrence of the same ingredient combinations in regional cuisines.

Flavor Pairing Hypothesis: "Foods that share many ***flavor compounds*** go well together."

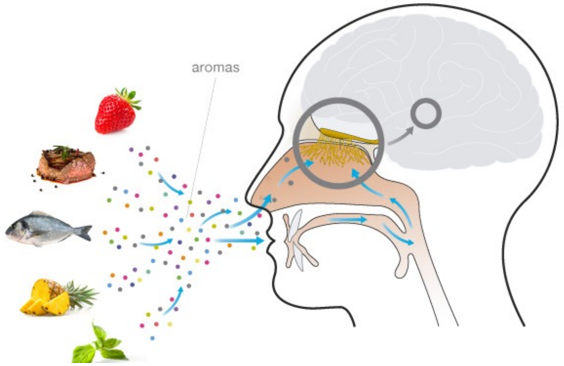
Heston Blumenthal (The Big Fat Duck Cookbook, 2008)

caviar and white chocolate; snail porridge; bacon-and-egg ice cream.

Flavor Compounds: Chemical compounds *distinct from the five tastes.*

10s-100s of different flavor compounds per food ingredient.

Olfaction (orthonasal and retronasal aroma detection)
is the main contributor to flavor perception.

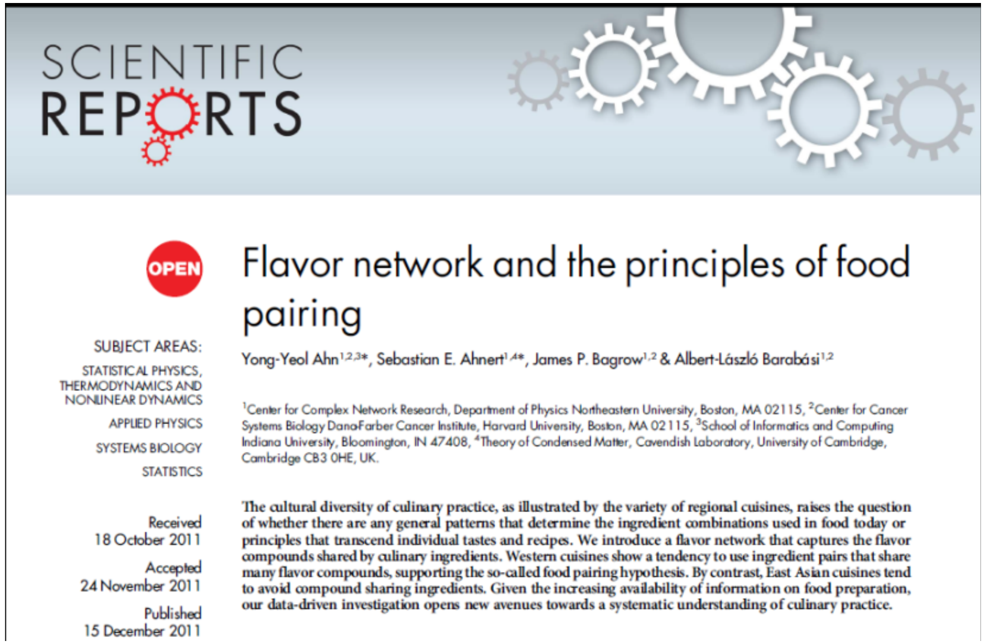


but other contributors include:

"Full understanding of flavor perception is central to preventing diseases such as hypertension, obesity, heart disease, diabetes and some cancers- i.e., diseases that are strongly impacted by food choices. Rather than being secondary senses, the chemical senses of flavor take a primary role when it comes to major issues of human health."

Beauchamp GK and Mennella JA. *Digestion* 2011;83(suppl 1):1–6

Computational Exploration and Test of Food Pairing Hypothesis


SCIENTIFIC REPORTS

OPEN

Flavor network and the principles of food pairing

Yong-Yeol Ahn[1,2,3]*, Sebastian E. Ahnert[1,4]*, James P. Bagrow[1,2] & Albert-László Barabási[1,2]

[1]Center for Complex Network Research, Department of Physics Northeastern University, Boston, MA 02115, [2]Center for Cancer Systems Biology Dana-Farber Cancer Institute, Harvard University, Boston, MA 02115, [3]School of Informatics and Computing Indiana University, Bloomington, IN 47408, [4]Theory of Condensed Matter, Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK.

SUBJECT AREAS:
STATISTICAL PHYSICS, THERMODYNAMICS AND NONLINEAR DYNAMICS
APPLIED PHYSICS
SYSTEMS BIOLOGY
STATISTICS

Received
18 October 2011

Accepted
24 November 2011

Published
15 December 2011

The cultural diversity of culinary practice, as illustrated by the variety of regional cuisines, raises the question of whether there are any general patterns that determine the ingredient combinations used in food today or principles that transcend individual tastes and recipes. We introduce a flavor network that captures the flavor compounds shared by culinary ingredients. Western cuisines show a tendency to use ingredient pairs that share many flavor compounds, supporting the so-called food pairing hypothesis. By contrast, East Asian cuisines tend to avoid compound sharing ingredients. Given the increasing availability of information on food preparation, our data-driven investigation opens new avenues towards a systematic understanding of culinary practice.

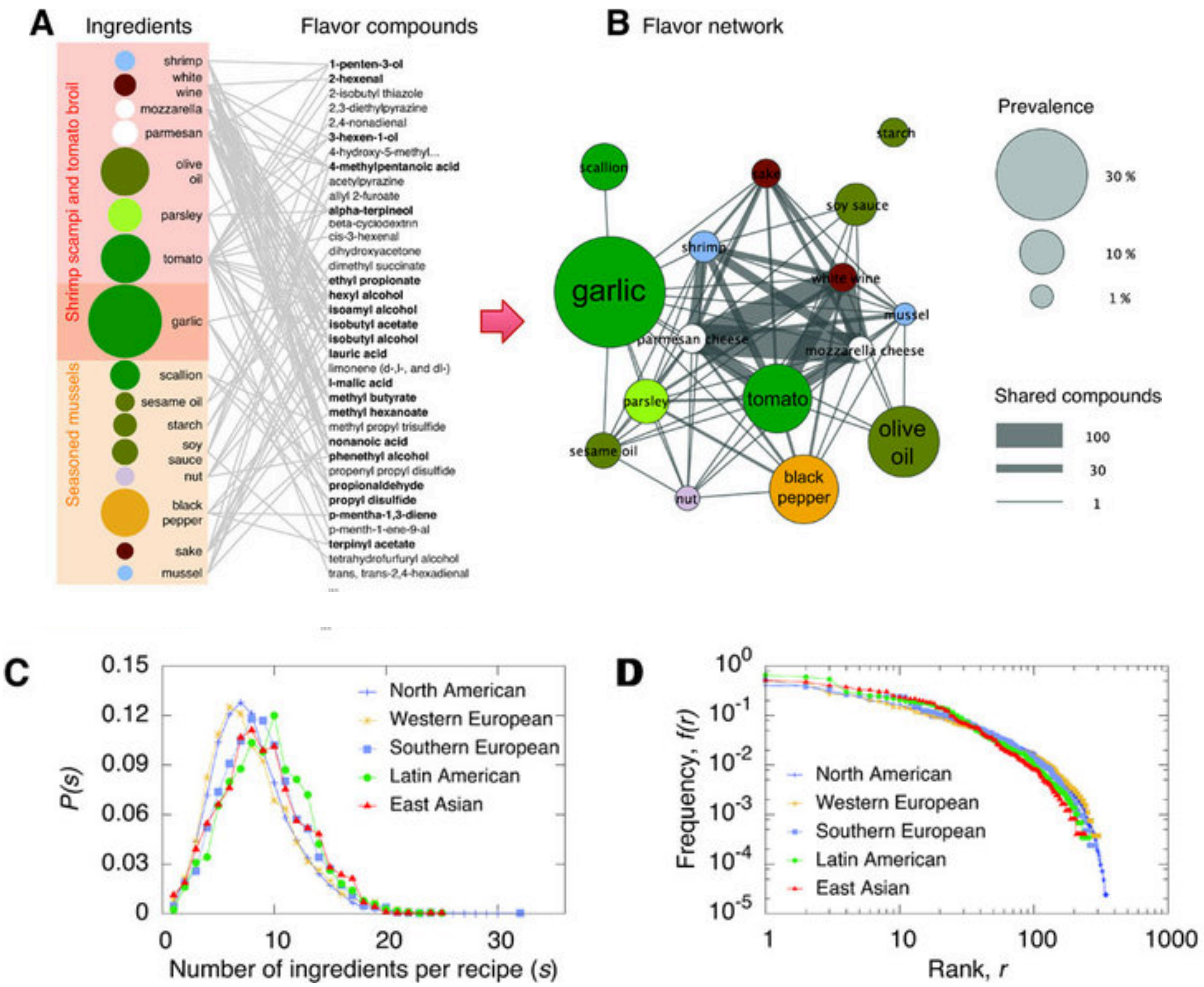
● Ingredient combinations preferred by humans across 5 cuisines were mined from 56,498 on-line recipe repositories: *epicurious.com*, *allrecipes.com*, and *menupan.com.*
Cuisines: North American, Western Europe, Mediterranean, Latin American, East Asian

● Identifies 381 ingredients used in recipes throughout the world.

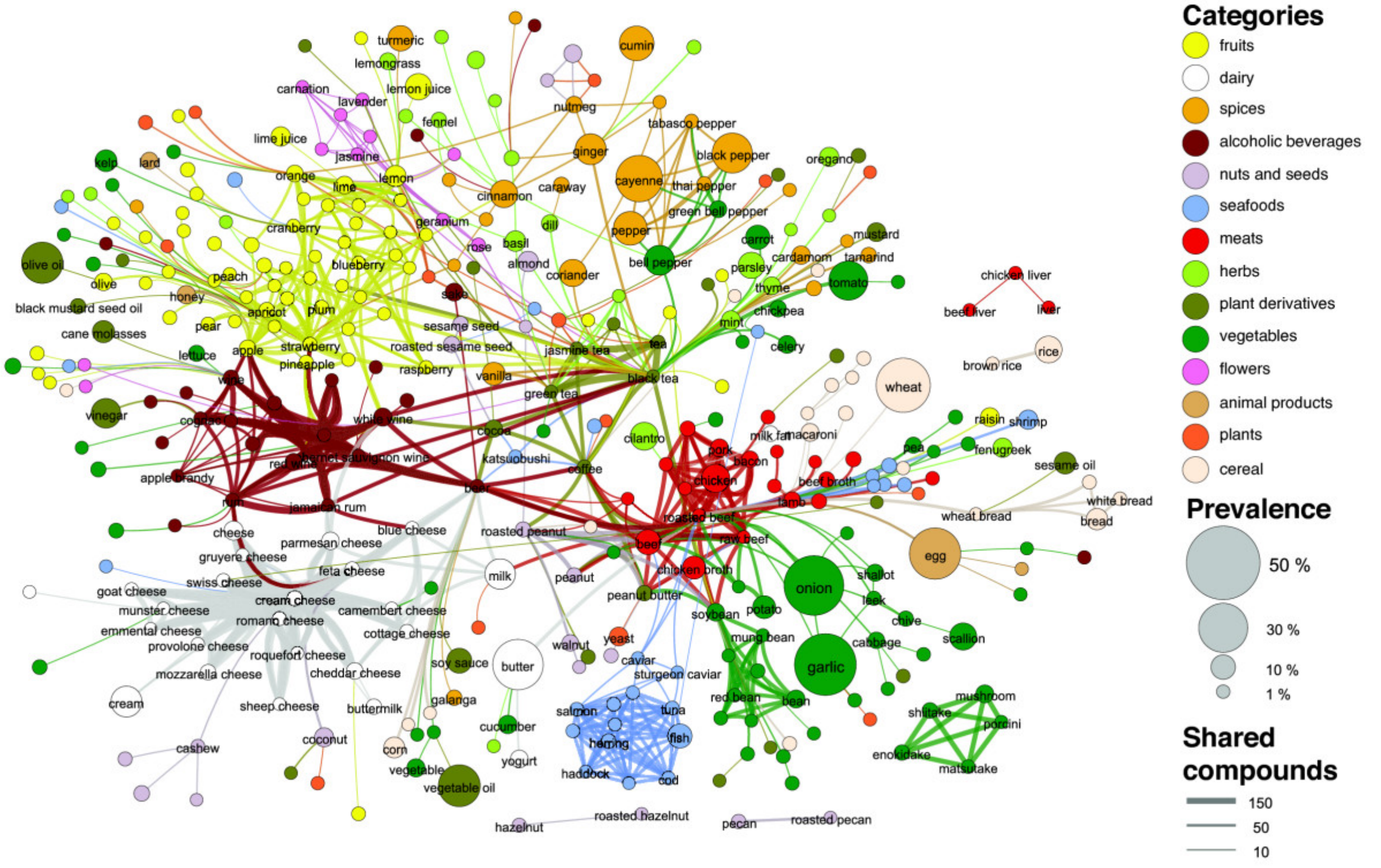
● 1,021 flavor compounds known for these ingredients (*Fenaroli's Handbook of Flavor Ingredients, 5th edition)*

Bipartite Weighted Flavor Network Linking Flavor Compounds to the Ingredient(s) That Contain It

(Ahn et al, 2011)



Statistically Significant Backbone of the Entire Flavor Network



Can Now Test Food Pairing Hypothesis Reformulated As:

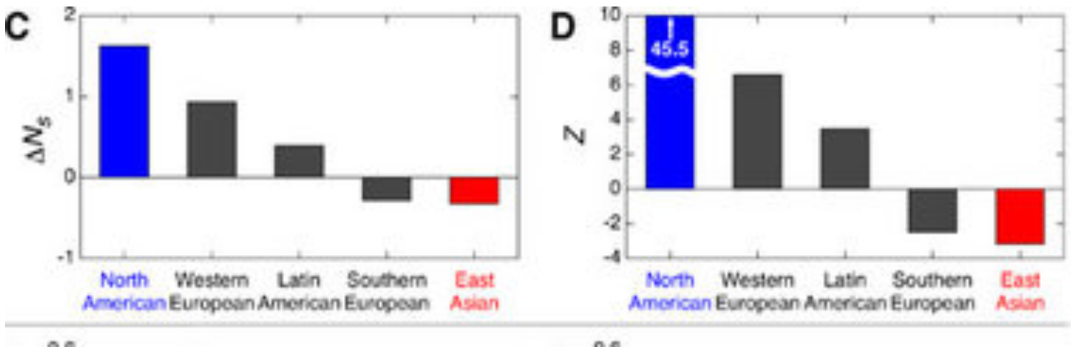
"Are ingredient pairs that are strongly linked in the Flavor Network used in human cuisines more frequently (support for hypothesis) or less frequently than expected by random.

- Data for ingredient combinations preferred by humans available in the body of 56,498 recipes.

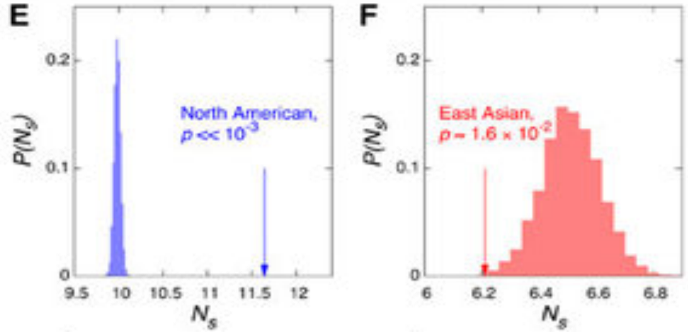
So What Did They Find Out?

Support For The Flavor Pairing Hypothesis is Cuisine-Specific

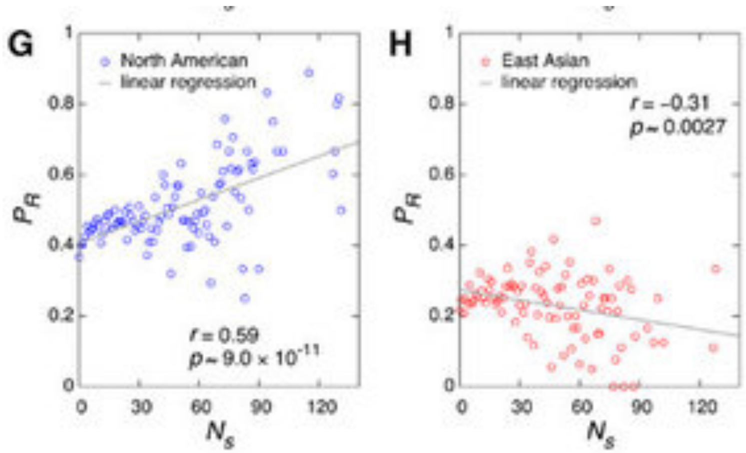
1. As compared with 10,000 random recipe datasets, statistically significant use of ingredients sharing flavor compounds in North American and Western European cuisines, but avoidance of ingredients sharing flavor compounds in East Asian (and Mediterranean) cuisines.



Ahn et al, 2001.

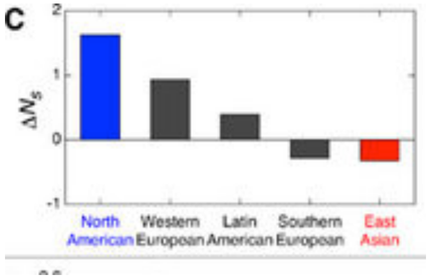


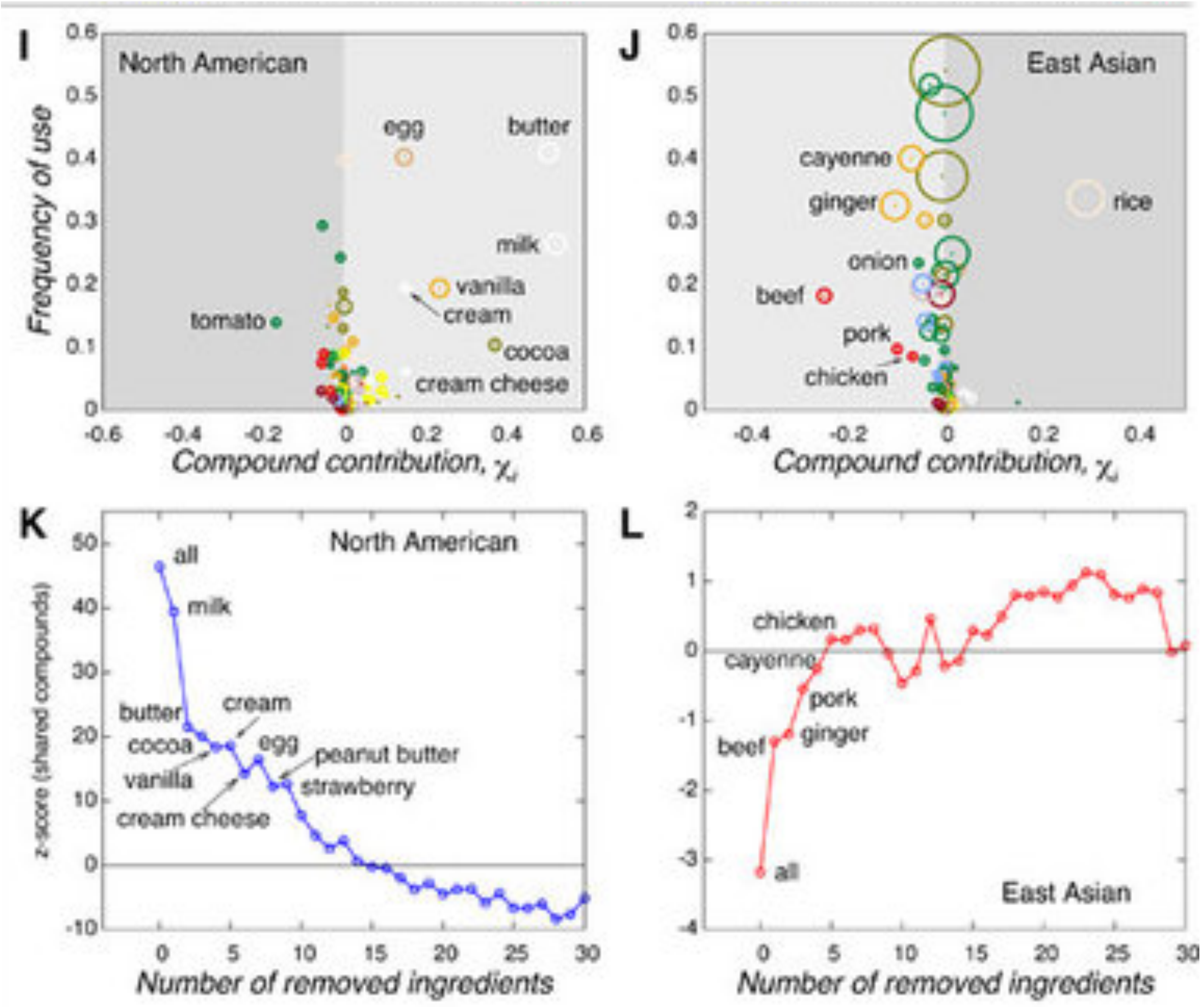
2. In North American cuisine, the likelihood that two ingredients are used in a recipe is correlated with the number of flavor compounds they share. In East Asian cuisine, ingredients with more shared flavor compounds are *less likely* to be used together.



Ahn et al, 2001.

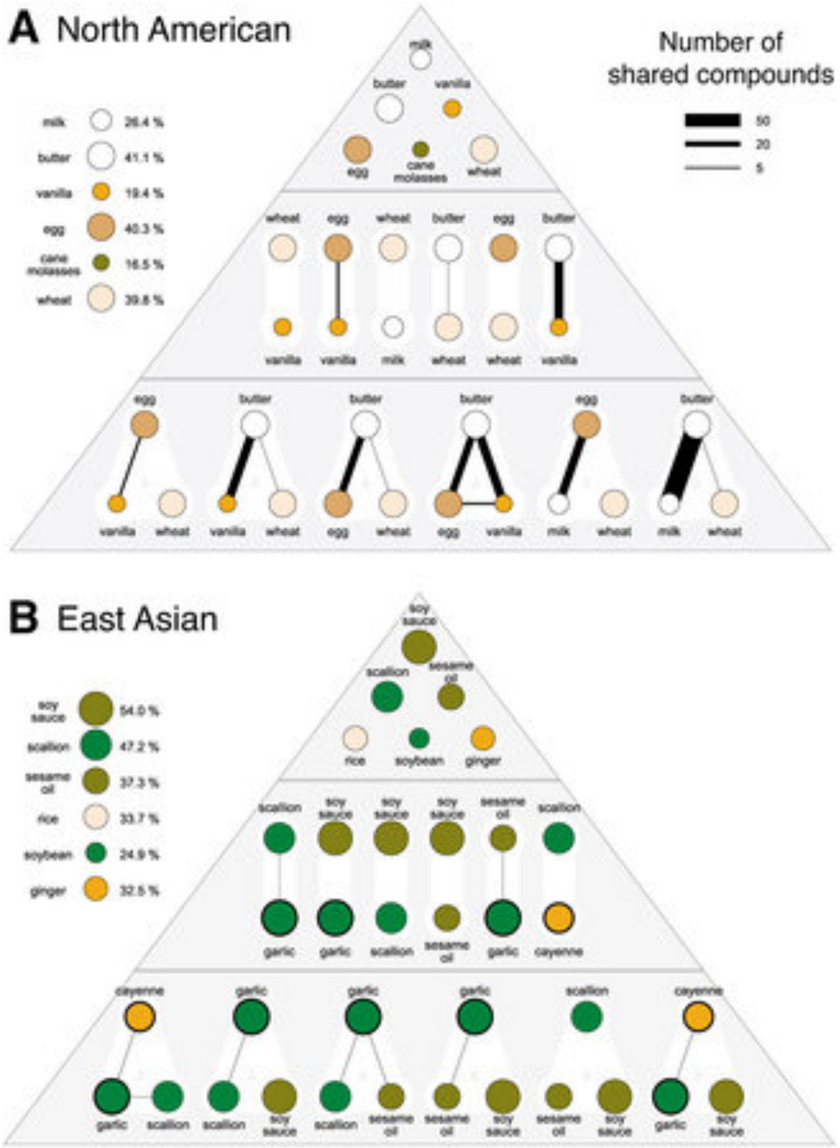
3. Food pairing effect (ΔNs) in a particular cuisine is driven by a few ingredients that are used frequently



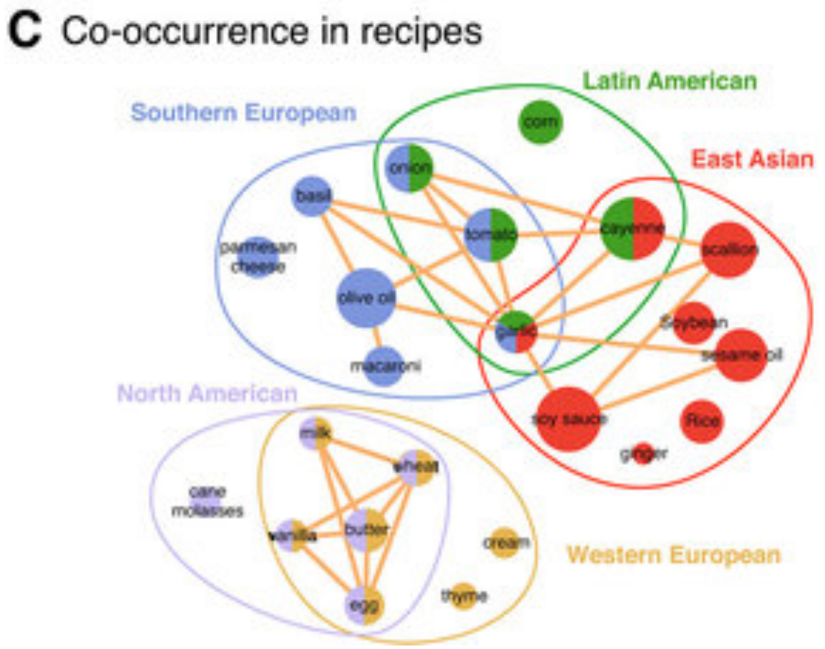


4. Identification of Pairings in Regional Cuisines That Are "Flavor Principles" (Rozin, 1973)

Six most 'authentic' ingredients*



With respect to signature ingredient combinations, Mediterranean cuisine is closer to Latin American than to Western European cuisine.



* the difference between the prevalence of an ingredient in a cuisine and its prevalence in all other cuisines.

Flavor Pairing Hypothesis Has been Extended to Other Cuisines and Historical Contexts

Flavor Pairing as a 'Fitness' Component in an Evolutionary Model of Recipes as Cultural Replicators (Memes)

Kinouchi, O et al. *New Journal of Physics* 10, 073020, 2008.

T, number of generations

K, ingredients per recipe compared to average for the cookbook

fi, fitness (0-1) of each ingredient (nutritional value, ***flavor pairing?***, availability, cost, etc)

L, number of ingredients ('loci') in each recipe to be 'mutated'

R_0, number of initial recipes

M, ratio of the size of ingredient pool to recipe pool

IOP Institute of Physics DEUTSCHE PHYSIKALISCHE GESELLSCHAFT

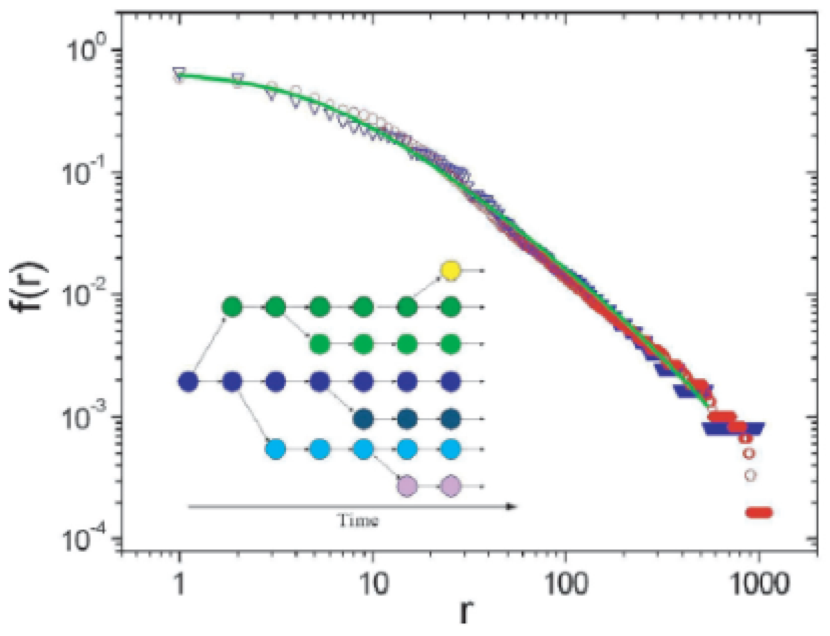


Figure 3. Frequency-rank plot for the Laurousse cookery book (triangles) fitted by a Zipf–Mandelbrot curve (solid) and by the model (circles, average of five runs). Inset: schematic view of the copy-mutate growth process. At each time step, a randomly chosen 'mother' recipe generates a mutated daughter recipe. Notice that there is no recipe extinction.

Figure 1
Flavour network . Culinary ingredients (circles) and their chemical relationship are illustrated [4]. The colour of each ingredient represents the food category that the ingredient belongs to, and the size of an ingredient is proportional to the usage frequency (collected from online recipe databases: epicurious.com, allrecipes.com, menupan.com). Two culinary ingredients are connected if they share many flavour compounds. We extracted the list of flavor compounds in each ingredient from them and then applied a backbone extraction method by Serrano et al. [6] to pick statistically significant links between ingredients. The thickness of an edge represents the number of shared flavour compounds. To reduce clutter, edges are bundled based on the algorithm by Danny Holten (http://www.win.tue.nl/~dholten/).

New Journal of Physics
The open-access journal for physics

The non-equilibrium nature of culinary evolution

Osame Kinouchi[1], Rosa W Diez-Garcia[2], Adriano J Holanda[1], Pedro Zambianchi[3] and Antonio C Roque[1,4]

[1] Departamento de Física e Matemática, FFCLRP, Universidade de São Paulo, 14040-901 Ribeirão Preto, SP, Brazil
[2] Departamento de Clínica Médica, Curso de Nutrição e Metabolismo, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, 14040-901 Ribeirão Preto, SP, Brazil
[3] Departamento de Física, Universidade Tecnológica Federal do Paraná, Av. Sete de Setembro 3165, Centro, 80230-901 Curitiba, PR, Brazil
E-mail: antonior@ffclrp.usp.br

New Journal of Physics **10** (2008) 073020 (8pp)
Received 2 April 2008
Published 10 July 2008
Online at http://www.njp.org/
doi:10.1088/1367-2630/10/7/073020

Abstract. Food is an essential part of civilization, with a scope that ranges from the biological to the economic and cultural levels. Here, we study the statistics of ingredients and recipes taken from Brazilian, British, French and Medieval cookery books. We find universal distributions with scale invariant behaviour. We propose a copy-mutate process to model culinary evolution that fits our empirical data very well. We find a cultural 'founder effect' produced by the non-equilibrium dynamics of the model. Both the invariant and idiosyncratic aspects of culture are accounted for by our model, which may have applications in other kinds of evolutionary processes.

Hypothesis: Culinary recipes are cultural replicators ('memes') and culinary evolution can be modeled as a branching process by a "copy-mutate algorithm."

IOP Institute of Physics DEUTSCHE PHYSIKALISCHE GESELLSCHAFT

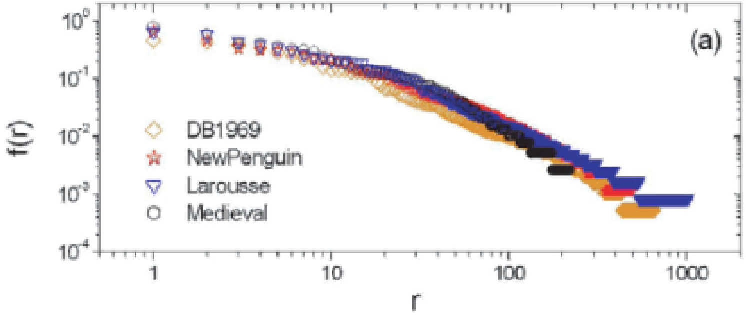
Table 1. Numerical characteristics for the considered cookery books.

Cookery book	No. of recipes	No. of ingredients	Average recipe size
Dona Benta (1946)	1786	491	6.7
Dona Benta (1969)	1894	657	7.1
Dona Benta (2004)	1564	533	7.4
Larousse Gastronomique (2004)[a]	1200	1005	10.8
New Penguin Cookery Book (2001)	878	489	9.5
Pleyn Delit (Medieval)	380	219	9.7

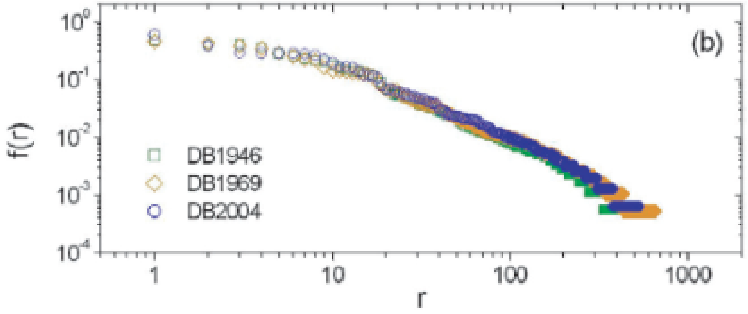
[a]Recipes have been sampled. The total number of recipes is above 3000.

f(r)= relative number of recipes that use the ingredient with rank, r

IOP Institute of Physics DEUTSCHE PHYSIKALISCHE GESELLSCHAFT



Cultural invariance



Temporal invariance

Figure 1. (a) Cultural invariance. Frequency-rank plot for different cookery books: *Pleyn Delit* (circles), *Dona Benta* 1969 (squares), *New Penguin* (stars) and *Larousse Gastronomique* (triangles). (b) Temporal invariance. Frequency-rank plot for *Dona Benta* 1946 (squares), 1969 (lozenges) and 2004 (circles).

Fitting the observed to an evolutionary model :

T, number of generations
K, ingredients per recipe compared to average for the cookbook
fi, fitness (0-1) of each ingredient (nutritional value, flavor, availability, cost, etc)
L, number of ingredients ('loci') in each recipe to be 'mutated'
R_0, number of initial recipes
M, ratio of the size of ingredient pool to recipe pool

Thus, starting at $t_0 = R_0$, at each time step there are R(t) recipes and MR(t) ingredients available.

The evolutionary model of copy mutation of recipes along with a selection mechanism generates indicates an out-of-equilibrium process: the number of recipes is never sufficient to fully explore the combinatorial space of ingredients. This means that the invasion of new high fitness ingredients and the elimination of initial low fitness ingredients never end, similar to the 'founder effect' of evolutionary theory. These persistent *founder ingredients* are like frozen 'cultural' accidents difficult to overcome.

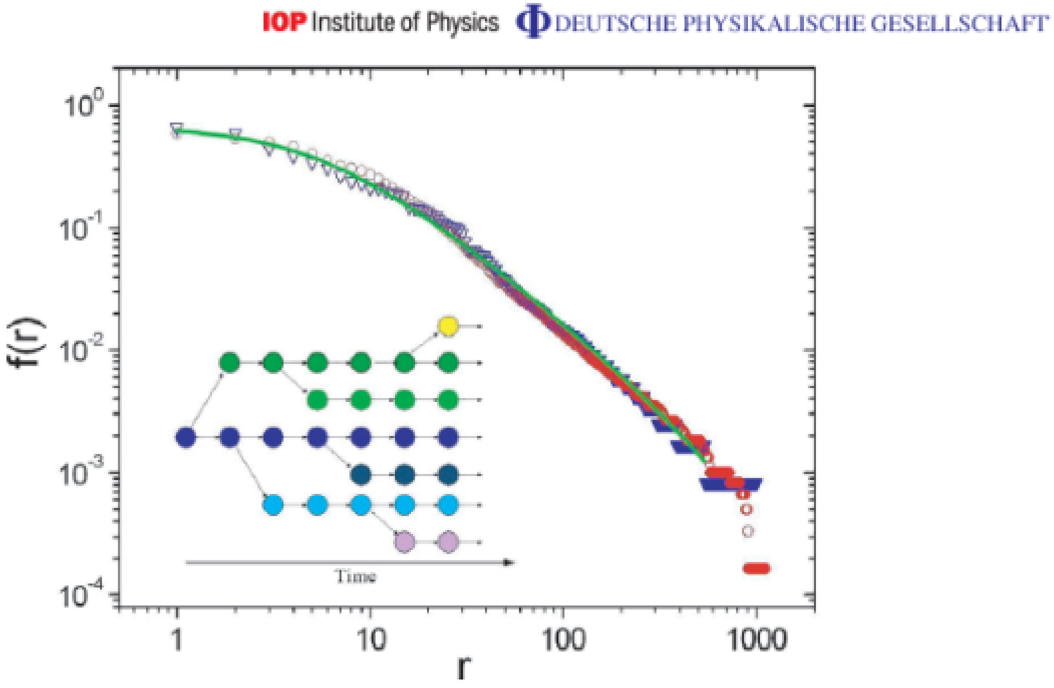


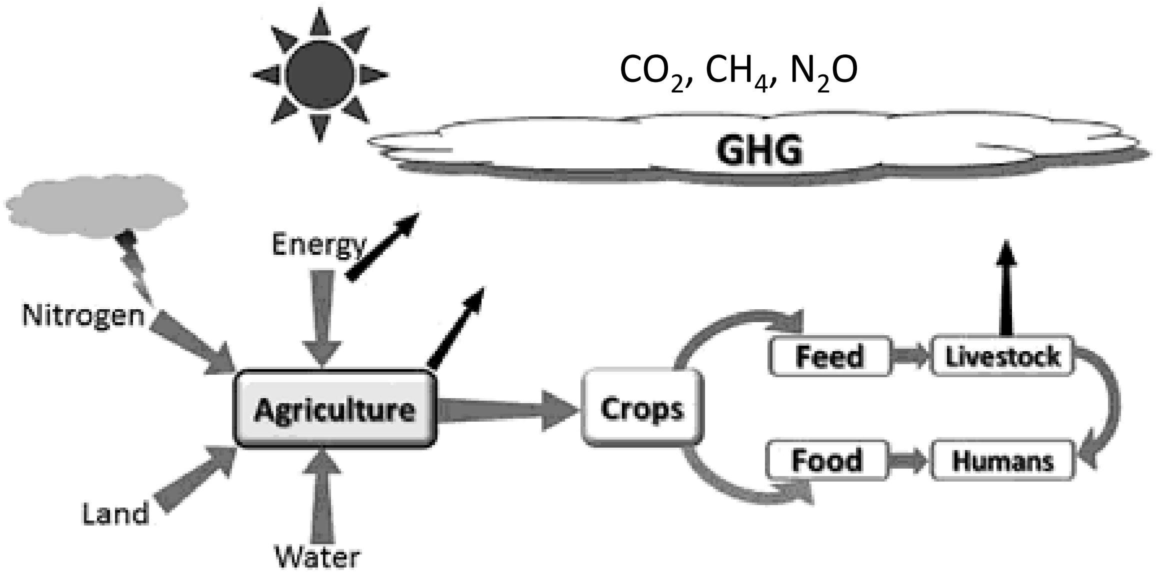
Figure 3. Frequency-rank plot for the Laurousse cookery book (triangles) fitted by a Zipf–Mandelbrot curve (solid) and by the model (circles, average of five runs). Inset: schematic view of the copy-mutate growth process. At each time step, a randomly chosen 'mother' recipe generates a mutated daughter recipe. Notice that there is no recipe extinction.

Speaker: Sebastian E. Ahnert, University of Cambridge

Abstract: The cultural diversity of culinary practice, as illustrated by the variety of regional cuisines, raises the question of whether there are any general patterns that determine the ingredient combinations used in food today or principles that transcend individual tastes and recipes. We introduce a flavor network that captures the flavor compounds shared by culinary ingredients. Western cuisines show a tendency to use ingredient pairs that share many flavor compounds, supporting the so-called food-pairing hypothesis. By contrast, East Asian cuisines tend to avoid compound sharing ingredients. Given the increasing availability of information on food preparation, our data-driven investigation opens new avenues towards a systematic understanding of culinary practice. In light of this we also discuss a variety of datasets on food ingredients and flavour compounds, including chef-curated flavour pairings, aroma compound concentrations, olfactory detection thresholds, and olfactory receptor responses. These datasets can be combined using large-scale data analysis in order to provide a deeper understanding of the impact that shared aroma compounds can have on perceived ingredient compatibility.

Obvious next tep: Identify New ingredient pairings beyond those in mental repositories of chefs

That is- establish a machine system for generating novel flavor (and thus ingredient) combinations that have never existed before.



CO_2, CH_4, N_2O
GHG
Energy
Nitrogen
Agriculture
Land
Water
Crops
Feed
Livestock
Food
Humans

Sustainable Protein Sources

Edited by

Sudarshan R. Nadathur, Janitha P.D. Wanasundara, and Laurie Scanlin

TABLE 2.5 Example Cost, Yield, and Footprint Impacts of Replacing Meat With Hydrated Textured Soy Protein

	Meat Replacements			
	0%	20%	30%	40%
Ingredients				
90% Lean beef. USD 6.31/kg (%)	75	49.48	36.5	25
50% Lean beef. USD 2.84/kg (%)	24.5	30	33	34.5
Soy protein as ISP or TSPC (%)	0	5.56	8.33	11.11
Water (%)	0	14.46	21.66	28.89
Salt (%)	0.5	0.5	0.5	0.5
Total (%)	100	100	100	100
Costs and Yields of Formulations				
Ingredients cost. Raw (USD/kg beef patty)	5.04	3.81	3.19	2.62
Cooking yield (%)	70	76	77	78
Ingredients cost. Cooked (USD/kg beef patty)	7.2	5.01	4.14	3.36
Footprint of Formulations[a]				
Carbon footprint (kg CO_2e/kg beef patty)	35.6	28.5	25	21.5
Blue water footprint (L/kg beef patty)	321	259	228	197
Land use footprint (m^2 year/kg beef patty)	262	210	184	159

[a]*The footprints associated with the creation of the various beef patty formulations were determined using the carbon, blue water, and land use footprint results provided for beef meat based on consequential modeling, and adjusted for protein content, which is assumed to be 20%. The footprints for soy protein are conservatively estimated to be the same as for ISP (90% protein) despite a protein content around 72% in the actual formulations. The footprints for salt and water are assumed to be zero for the sake of simplification.*
TSPC, Textured soy protein concentrate

Characteristic “beany and grassy” flavor limited early market growth of soybean protein products in Western-culture foods. The flavors, which are generally desired in Eastern culture foods, were put-offs for consumers without familiarity.

Characteristic "beany and grassy" flavor limited early market growth of soybean protein products in Western-culture foods. The flavors, which are generally desired in Eastern culture foods, were put-offs for consumers without familiarity.

Considerable research was done in the early 1960–70s that identified lipoxygenase enzyme (Lox) oxidation of lipids as a key factor. Over the years, several steps have been taken to significantly reduce this defect. These include breeding of seeds with low or no Lox, and reducing the content of oxidation-susceptible fatty acids, linoleic, and linolenic acids. Processors also adopted methods to maintain seeds at low enough water activity to inhibit Lox and then heat-inactivate Lox quickly during aqueous extraction processing. Unfortunately, since soybean oil is polyunsaturated oil, autoxidation can occur without enzymatic catalysis. For this reason, protein product processors also focused efforts on removing as much oil as possible during extraction, which resulted in better flavor and long-term flavor stability. Finally, soybean protein processors have borrowed separation and heat-processing techniques from other analogous industries (such as dairy) to move beyond the previous flavor limitations for Western-culture foods (Johnson et al., 2008).

Computational Gastronomy - Food in the Age of Data is a Royal Society International Scientific Seminar that aims to bring together leading researchers and practitioners from the fields of food science, computer science, neuroscience, sociology, and gastronomy to discuss these questions and exchange ideas. Recent research in this field has already shown how crowdsourcing, data mining, large-scale data analysis, machine learning, and network analysis can give us new insights into food choice, suggest novel ingredient combinations, and identify cultural, anthropological, psychological, nutritional and chemical factors that determine which foods we enjoy and why.

Ahnert *Flavour* 2013, **2**:4
http://www.flavourjournal.com/content/2/1/4

Flavour

OPINION Open Access

Network analysis and data mining in food science: the emergence of computational gastronomy

Sebastian E Ahnert

Abstract

The rapidly growing body of publicly available data on food chemistry and food usage can be analysed using data mining and network analysis methods. Here we discuss how these approaches can yield new insights both into the sensory perception of food and the anthropology of culinary practice. We also show that this development is part of a larger trend. Over the past two decades large-scale data analysis has revolutionized the biological sciences, which have experienced an explosion of experimental data as a result of the advent of high-throughput technology. Large datasets are also changing research methodologies in the social sciences due to the data generated by mobile communication technology and online social networks. Even the arts and humanities are seeing the establishment of 'digital humanities' research centres in order to cope with the increasing digitization of literary and historical sources. We argue that food science is likely to be one of the next beneficiaries of large-scale data analysis, perhaps resulting in fields such as 'computational gastronomy'.

Keywords: Networks, Data mining, Sensory science, Computational gastronomy, Flavour compounds

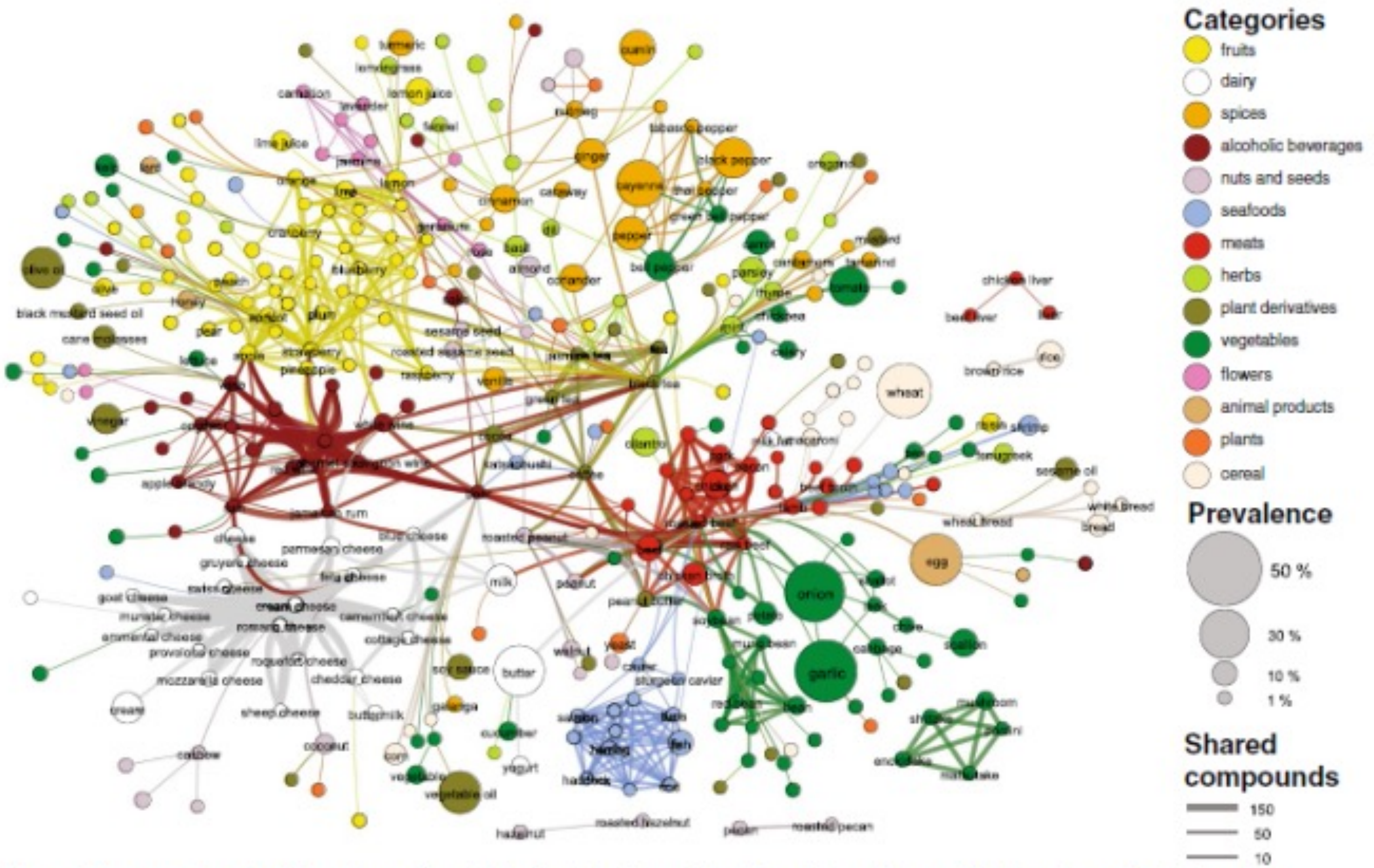


Figure 1 Flavour network. Culinary ingredients (circles) and their chemical relationship are illustrated [4]. The colour of each ingredient represents the food category that the ingredient belongs to, and the size of an ingredient is proportional to the usage frequency (collected from online recipe databases: epicurious.com, allrecipes.com, menupan.com). Two culinary ingredients are connected if they share many flavour compounds. We extracted the list of flavor compounds in each ingredient from them and then applied a backbone extraction method by Serrano *et al*. [6] to pick statistically significant links between ingredients. The thickness of an edge represents the number of shared flavour compounds. To reduce clutter, edges are bundled based on the algorithm by Danny Holten (http://www.win.tue.nl/~dholten/). © Yong-Yeol Ahn, Sebastian E Ahnert, James P. Bagrow, and Albert-László Barabási.

new techniques, textures and flavour combinations

Computational / Synthetic Gastronomy

“Cooking”- the preparation of food.
“Gastronomy” - the knowledge of whatever concerns man's nourishment

This, H. EMBO Rep. 2006 Nov; 7(11): 1062–1066.

Thank you for attending!

For more information, to join the team, or if you'd like to speak at a future event please contact:

- Kenny Westerman (Kenneth.Westerman@tufts.edu)
- Katherine Rancano (Katherine.Rancano@tufts.edu)
- Jessie Ellis (Jessica.Ellis@tufts.edu)

NewTrition: A discussion of new ideas and thoughts in nutrition and health through TED Talk-style conversations