Flavor network and the principles of food pairing

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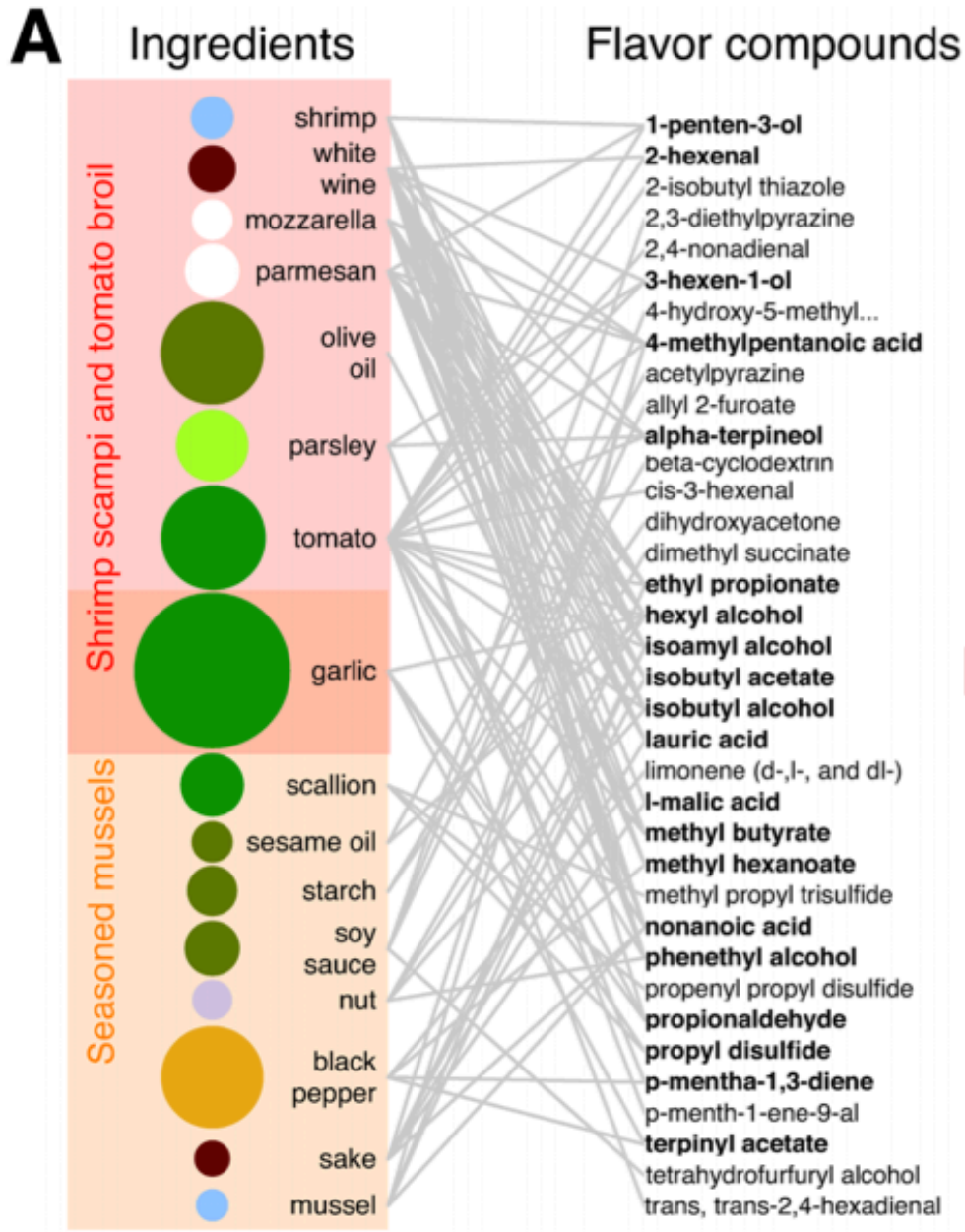
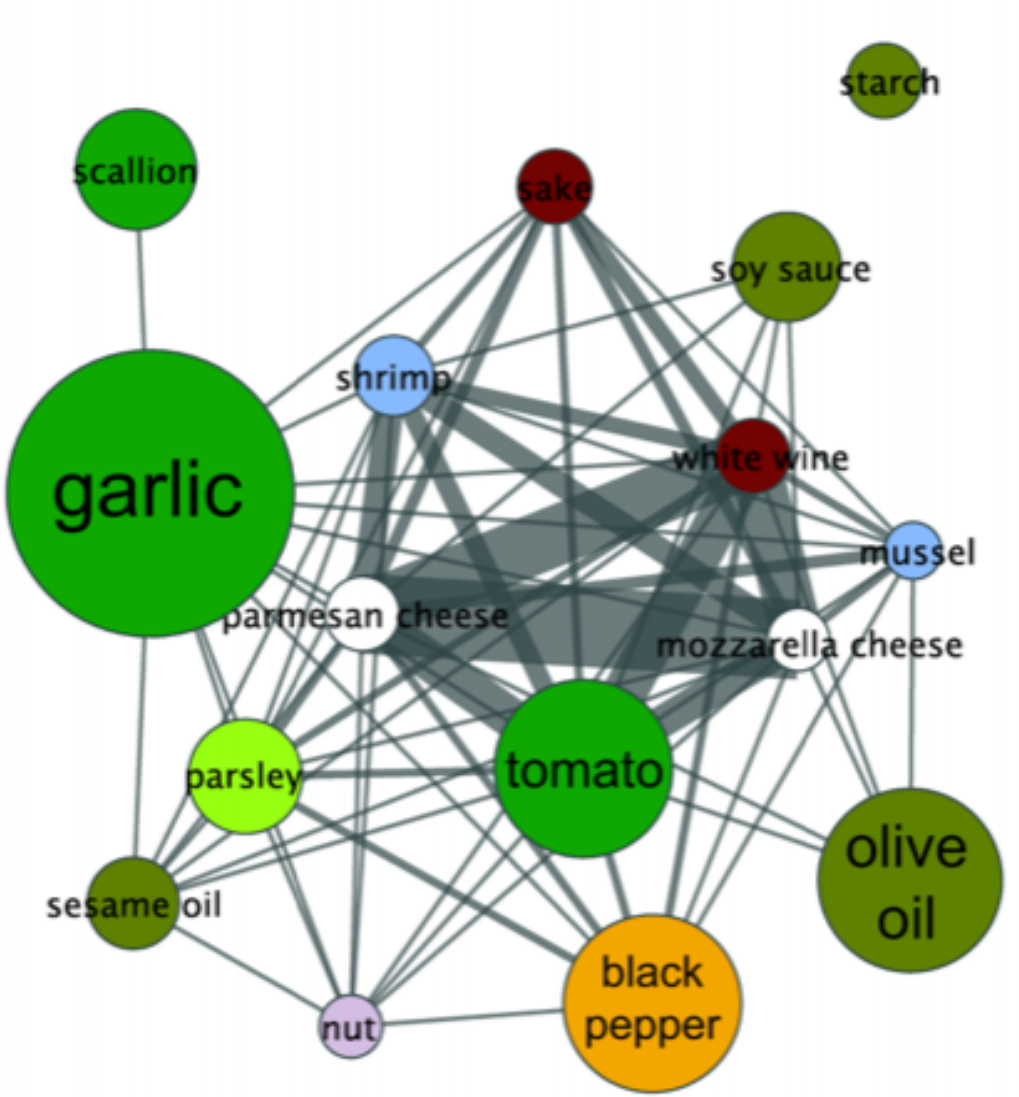
- Network-based approach to explore the impact of flavor compounds on ingredient combinations
  - Analyze 1021 flavor compounds of 381 ingredients from $57K$ recipes across 5 cuisines (North & Latin American, West & South European, East Asian)
  - Note: proportions of flavor compounds in ingredients ignored

Bipartite graph: Ingredients vs flavor compounds

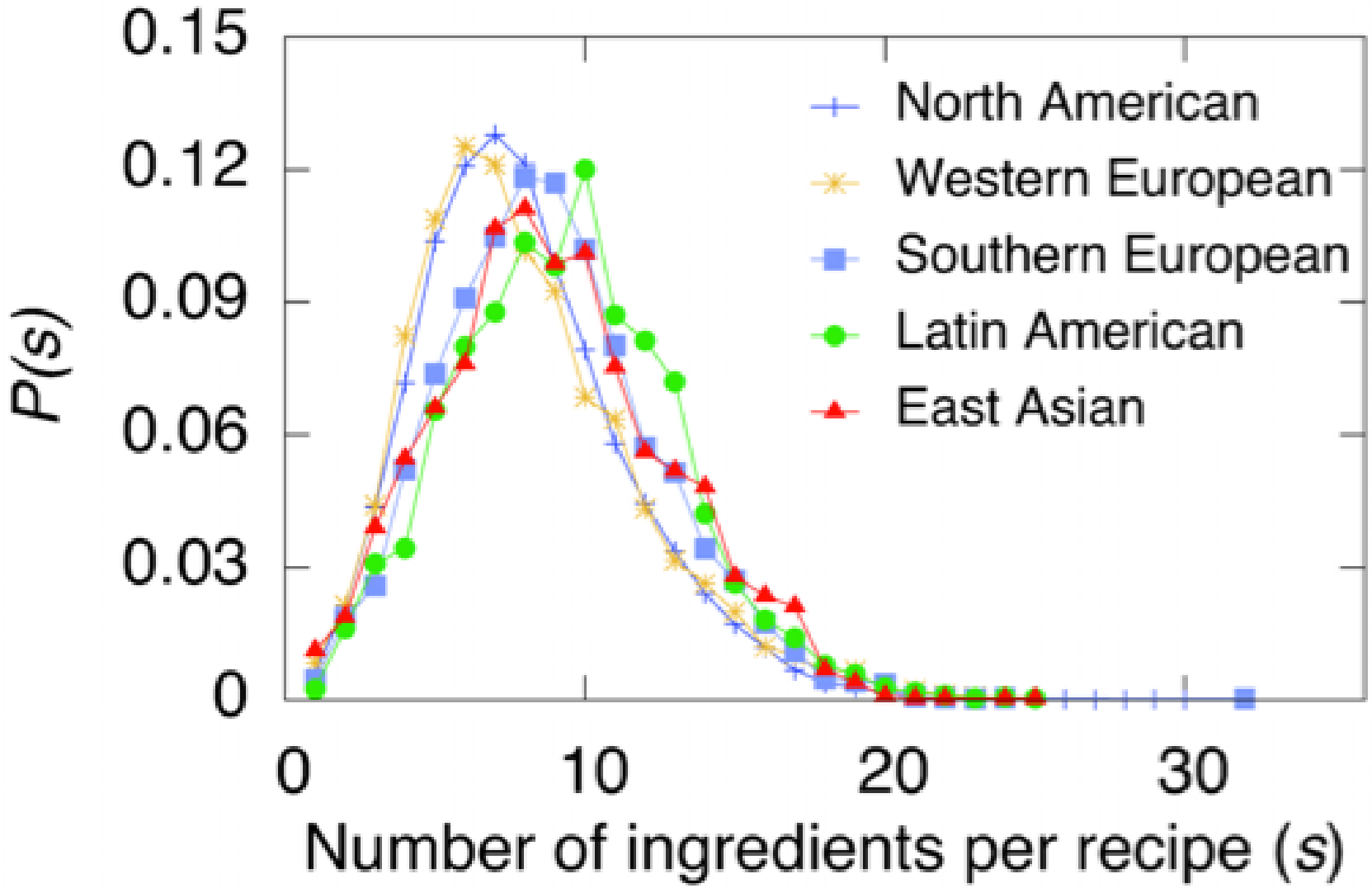


Flavor network

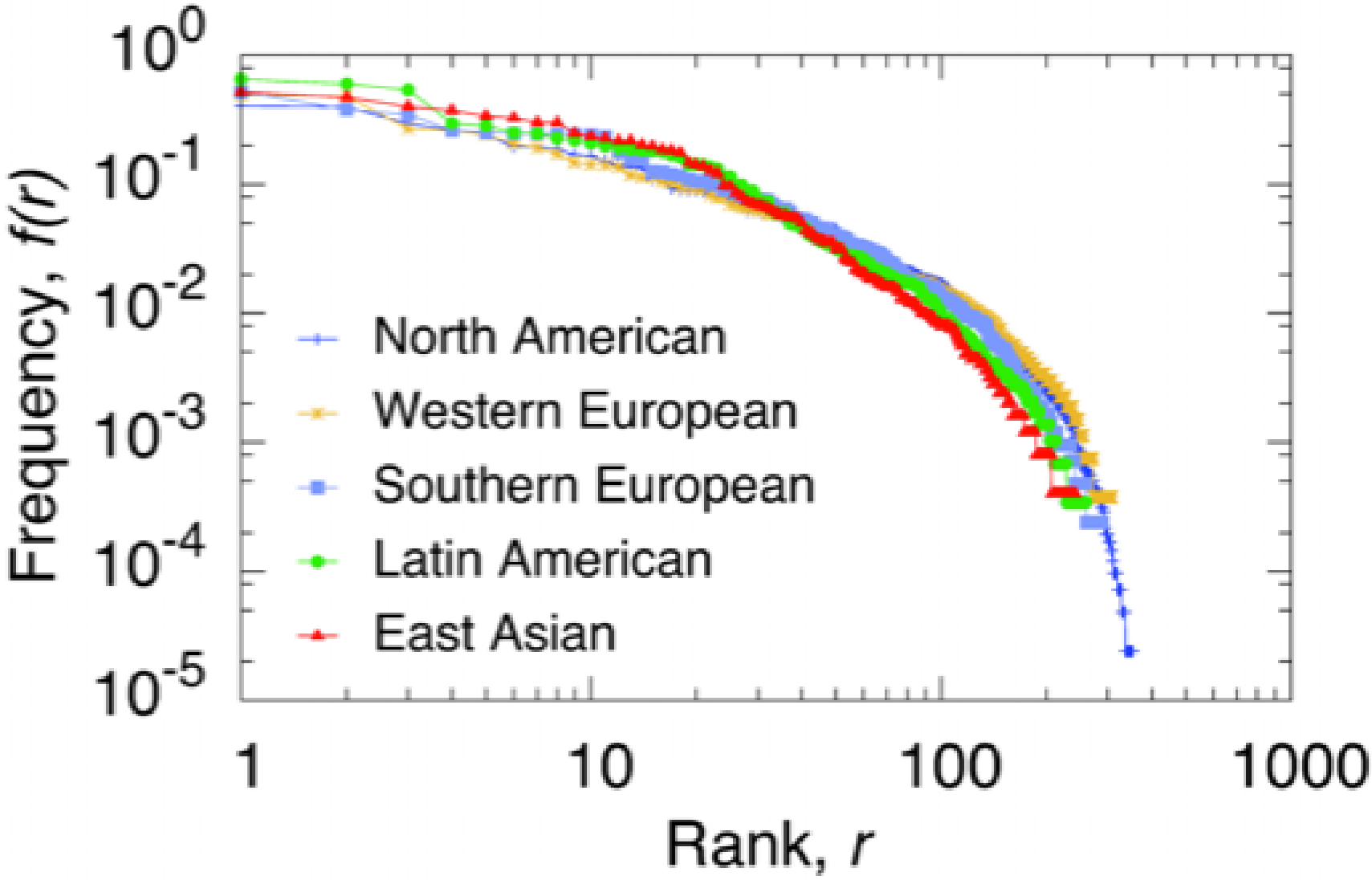


weight = number of shared components

Number of ingredients per recipe



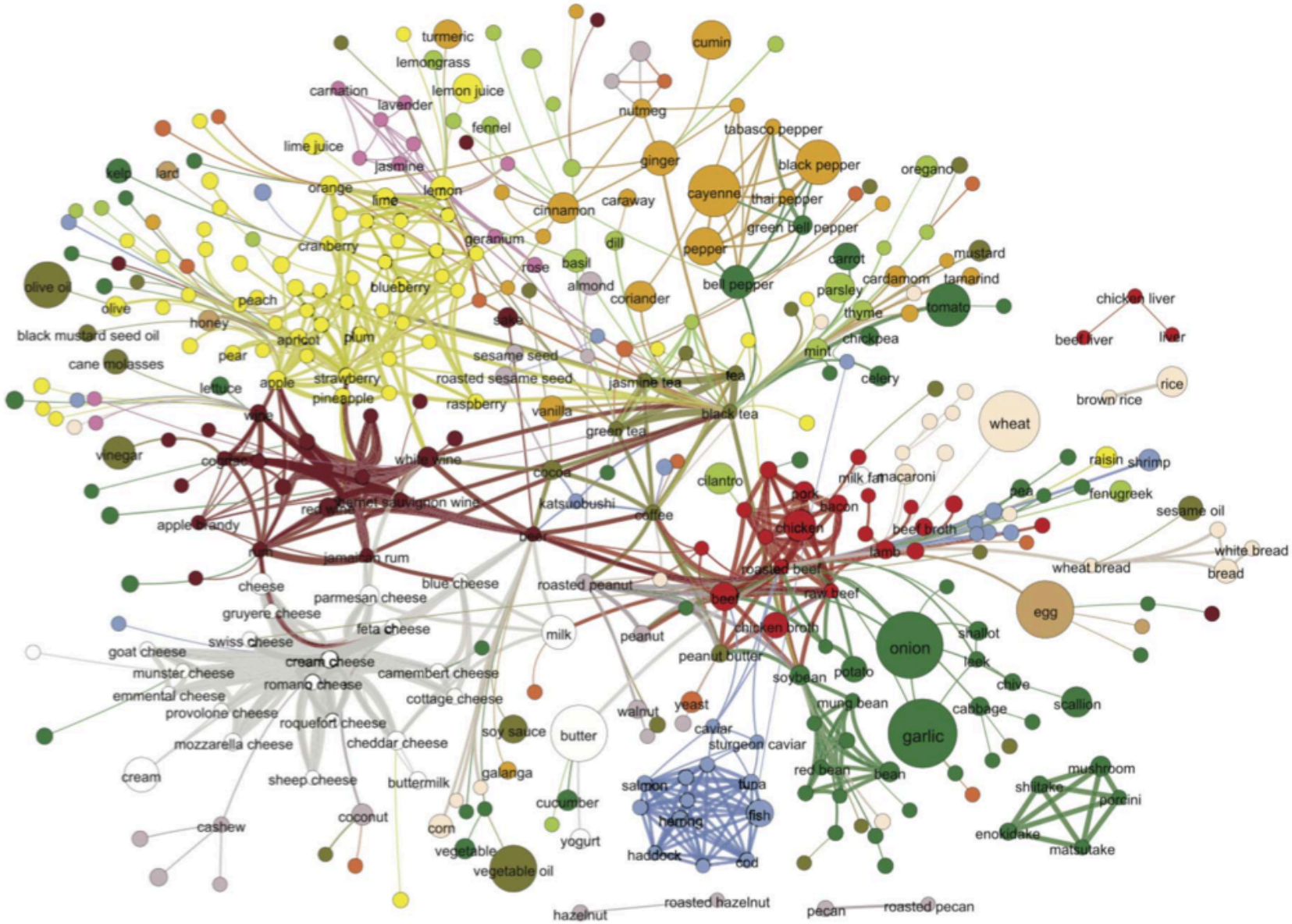
Frequency of ingredients in recipes



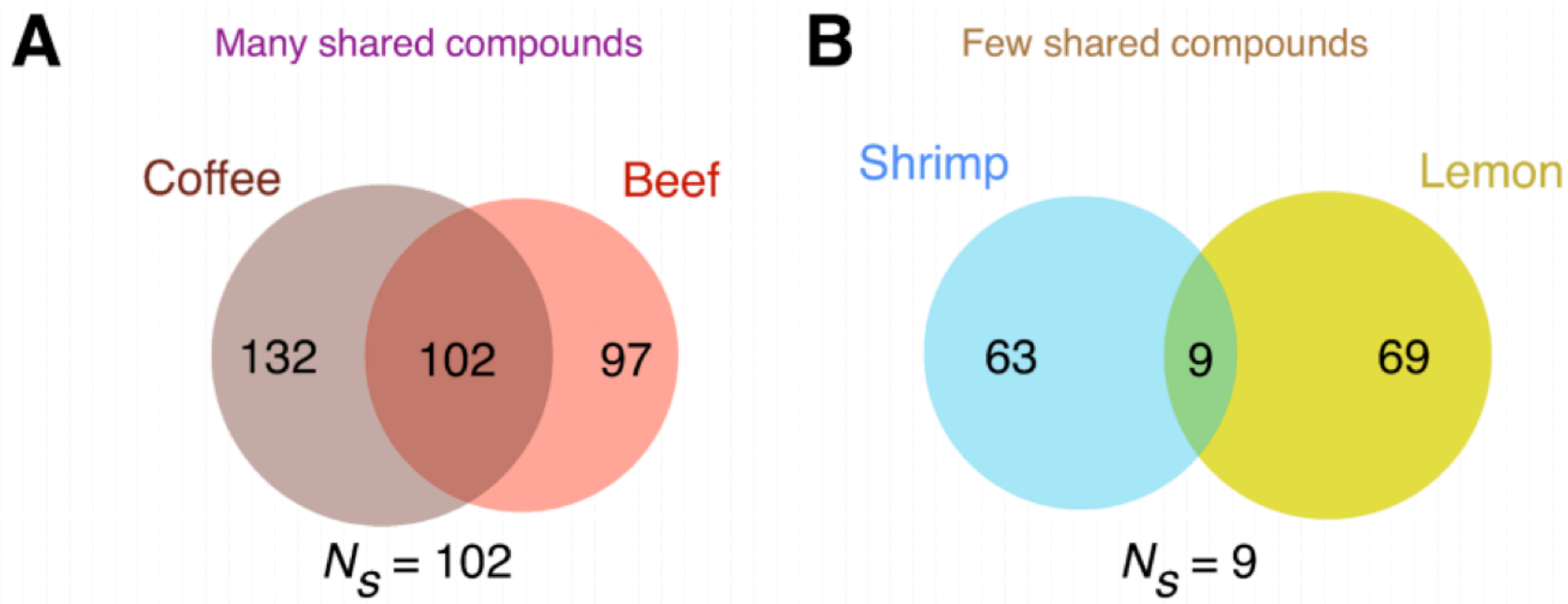
Backbone of flavor network

- several flavor compounds are shared by a large number of ingredients
- Flavor network is too dense for direct visualization (average degree ≈ 214)
- Backbone extraction method: statistically significant links for each ingredient

Backbone of flavor network



Shared compounds



Food pairing hypothesis

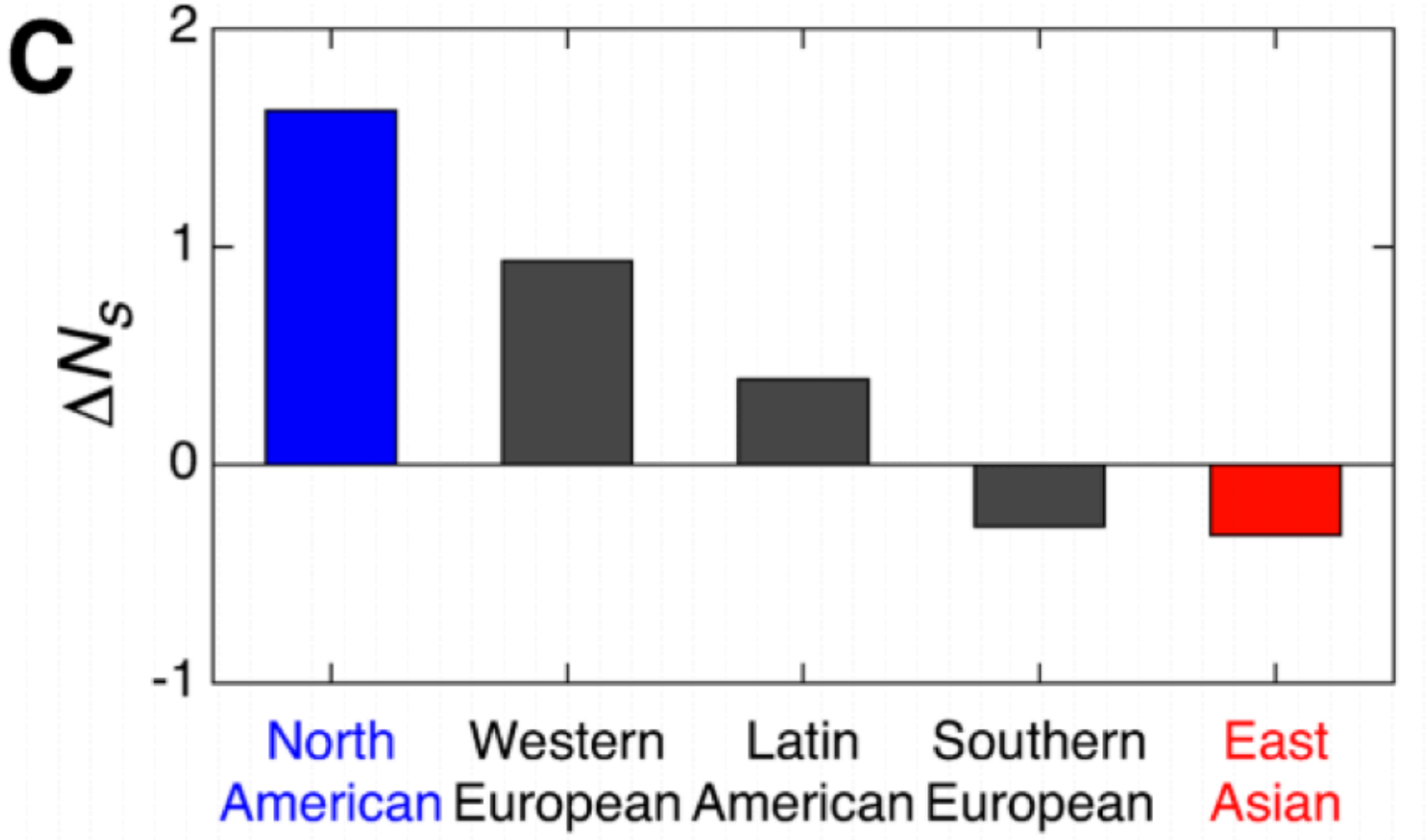
- Ingredients sharing flavor compounds are more likely to taste well together than ingredients that do not

$$N_s(R) = \frac{2}{n_R(n_R - 1)} \sum_{i,j \in R, i \neq j} \left| C_i \cap C_j \right|$$

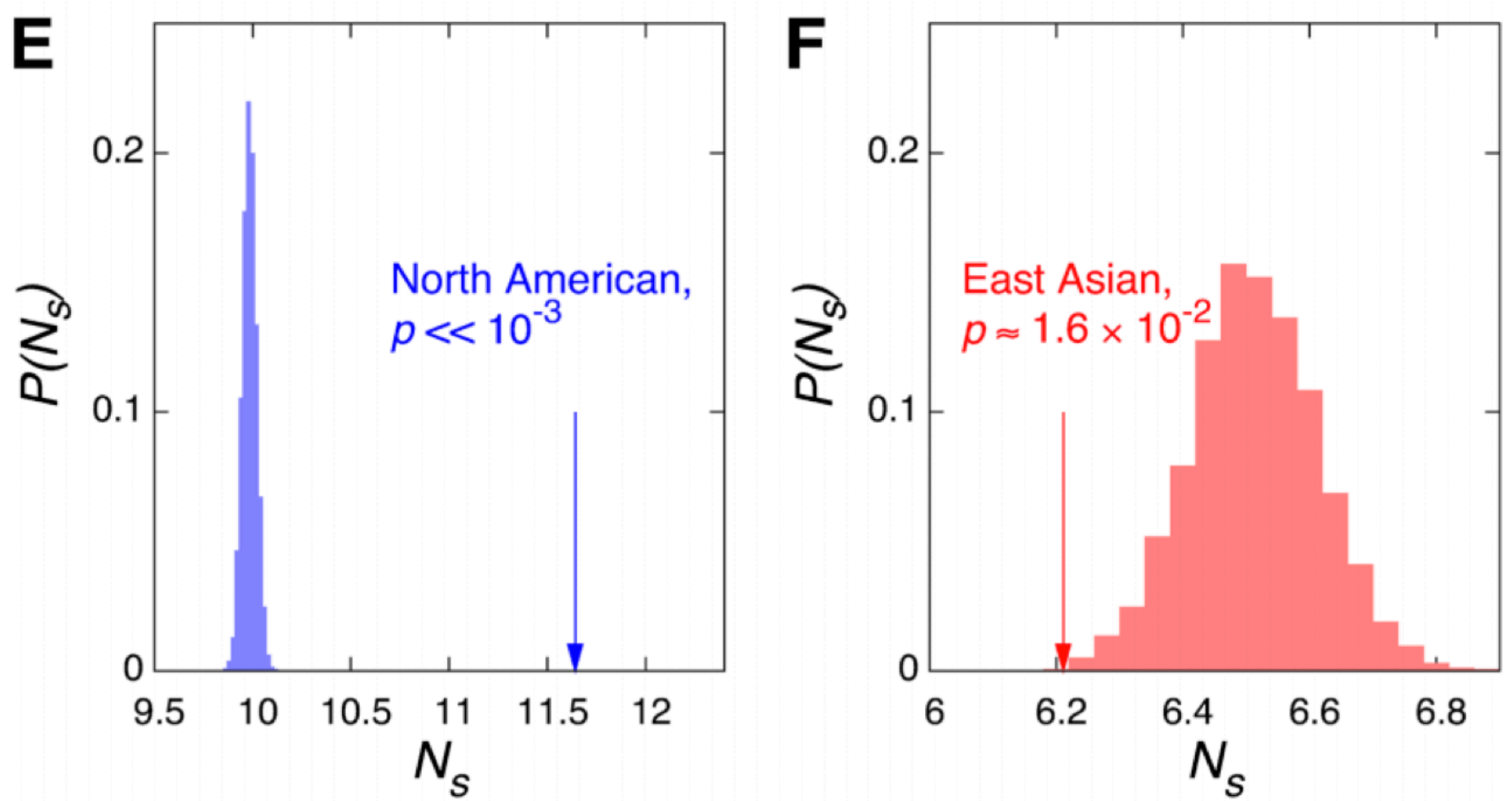
$$\Delta N_s = N_s^{\text{real}} - N_s^{\text{rand}}$$

- Note: Random model (null model) different for cuisines (to control for the frequency of a particular ingredient in a cuisine)

Food pairing hypothesis



Distribution of N_s for random recipes



Measuring ingredient contributions to shared compounds

- χ_i measures how much does an ingredient affect ΔN_s.
- Are there frequently used ingredients that affect food pairing?

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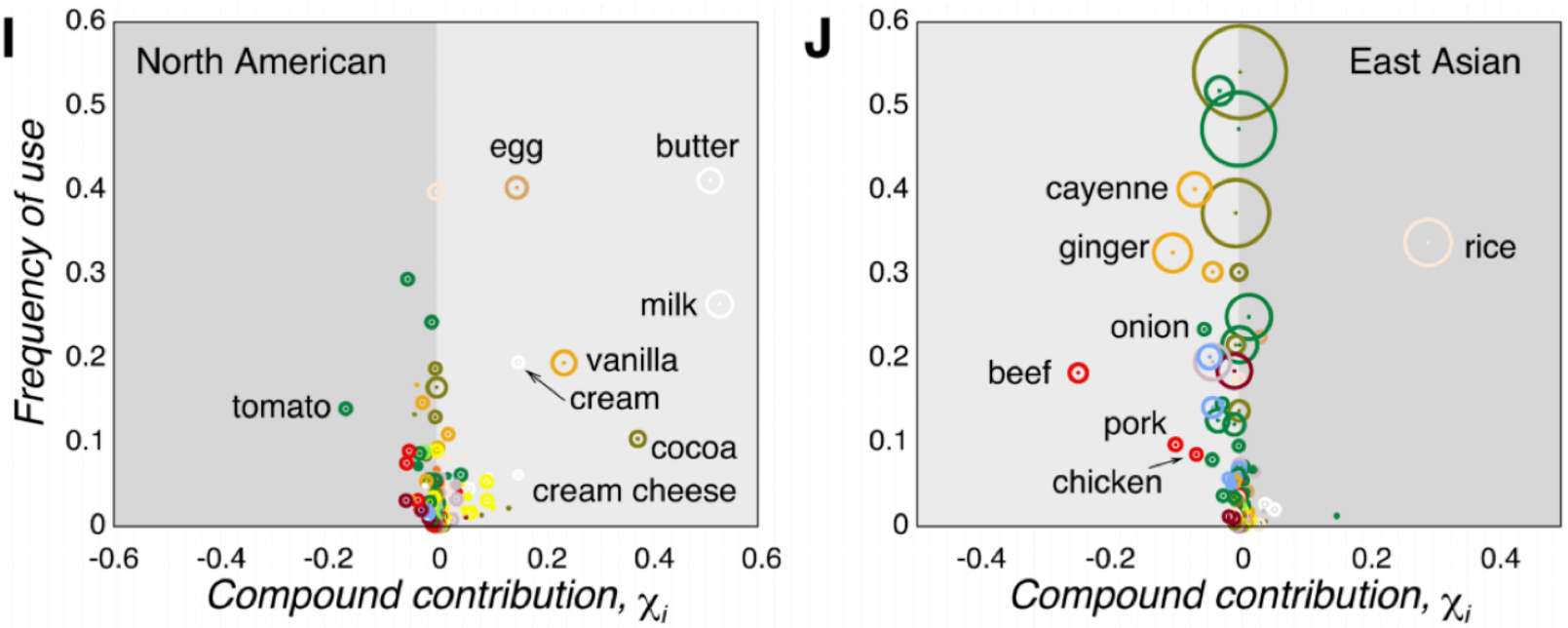


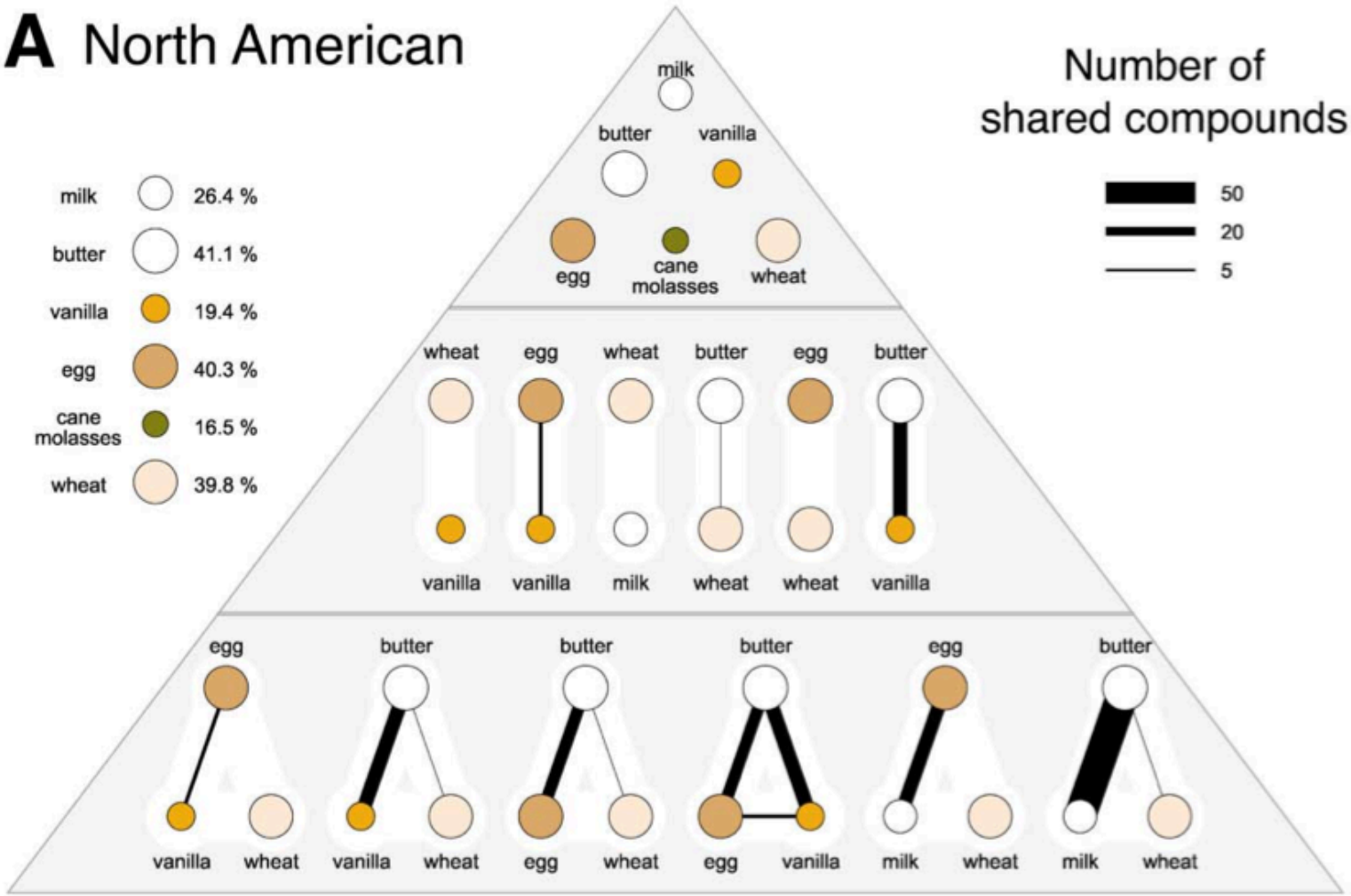
Flavor principle

- Flavor principle: the differences between regional cuisines can be reduced to a few key ingredients with specific flavors
- e.g. soy sauce leads to oriental taste
- Measuring authenticity:

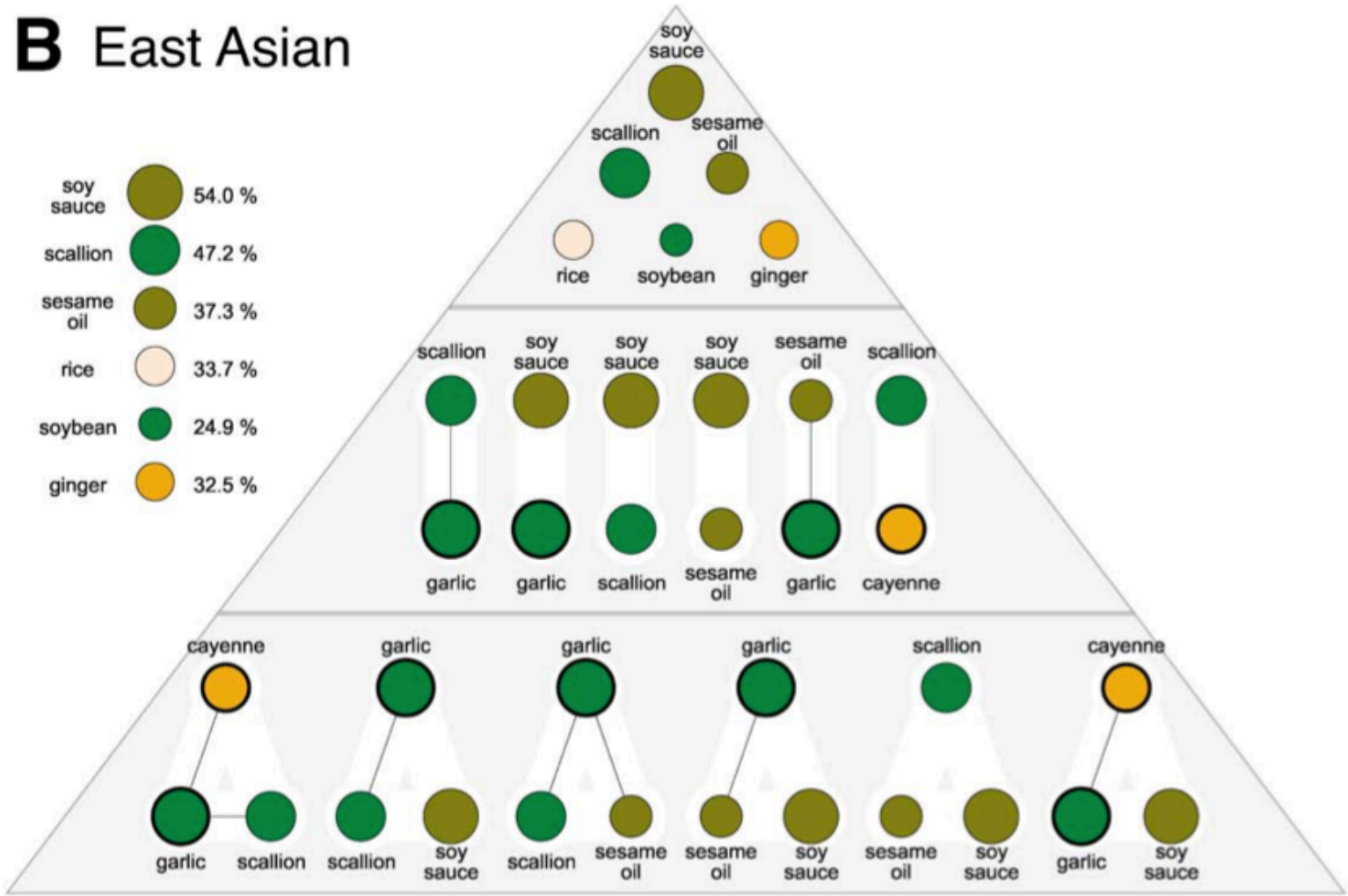
$$P_i^c = n_i^c / N_c$$

$$p_i^c = P_i^c - \left\langle P_i^{c'} \right\rangle_{c' \neq c}$$

- Create flavor pyramids with 6 most authentic ingredients, ingredient pairs and ingredient triplets



Note: co-occurring compounds share more compounds



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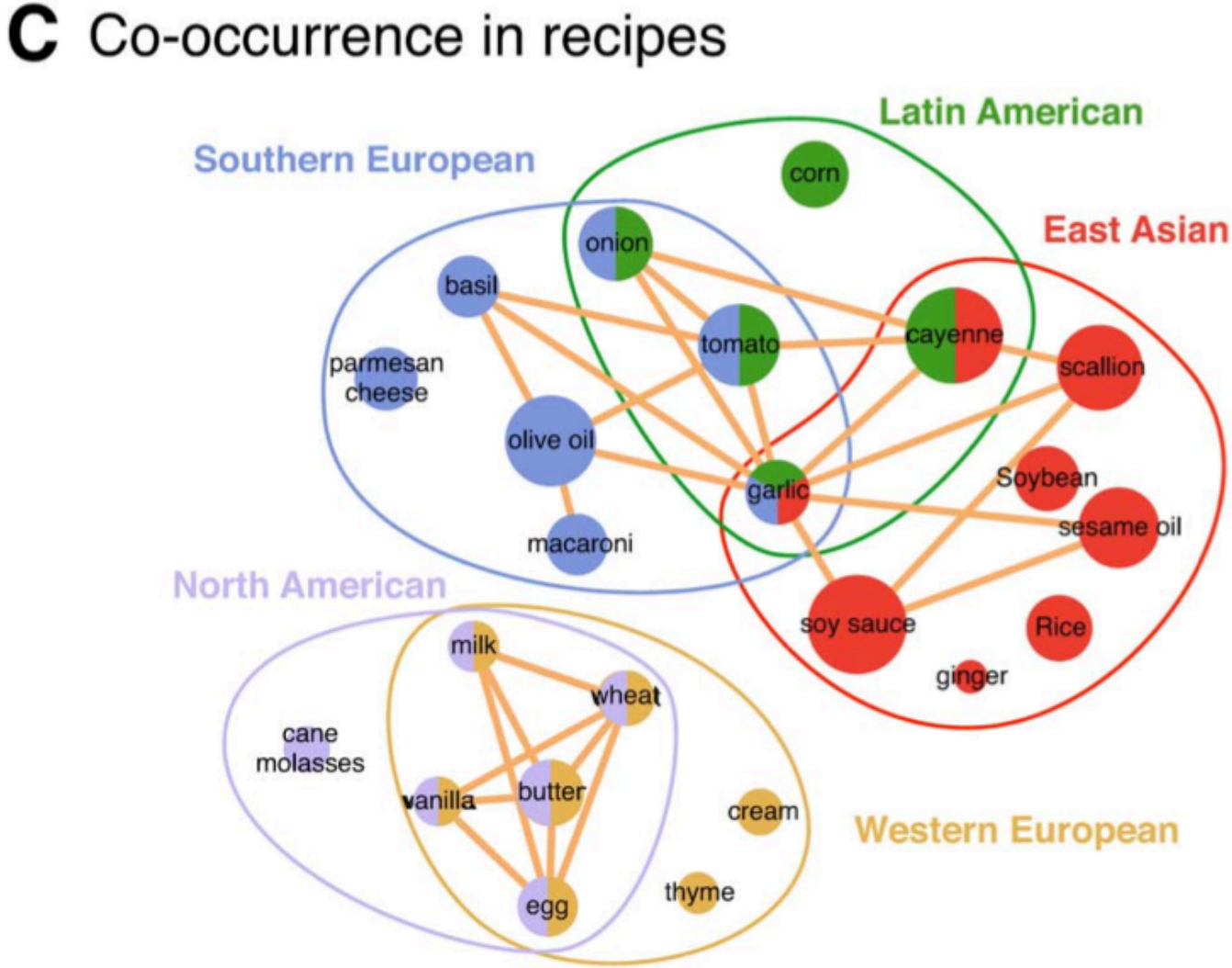
Measuring similarity between cuisines



Select the six most authentic ingredients in each regional cuisine

Thank you!

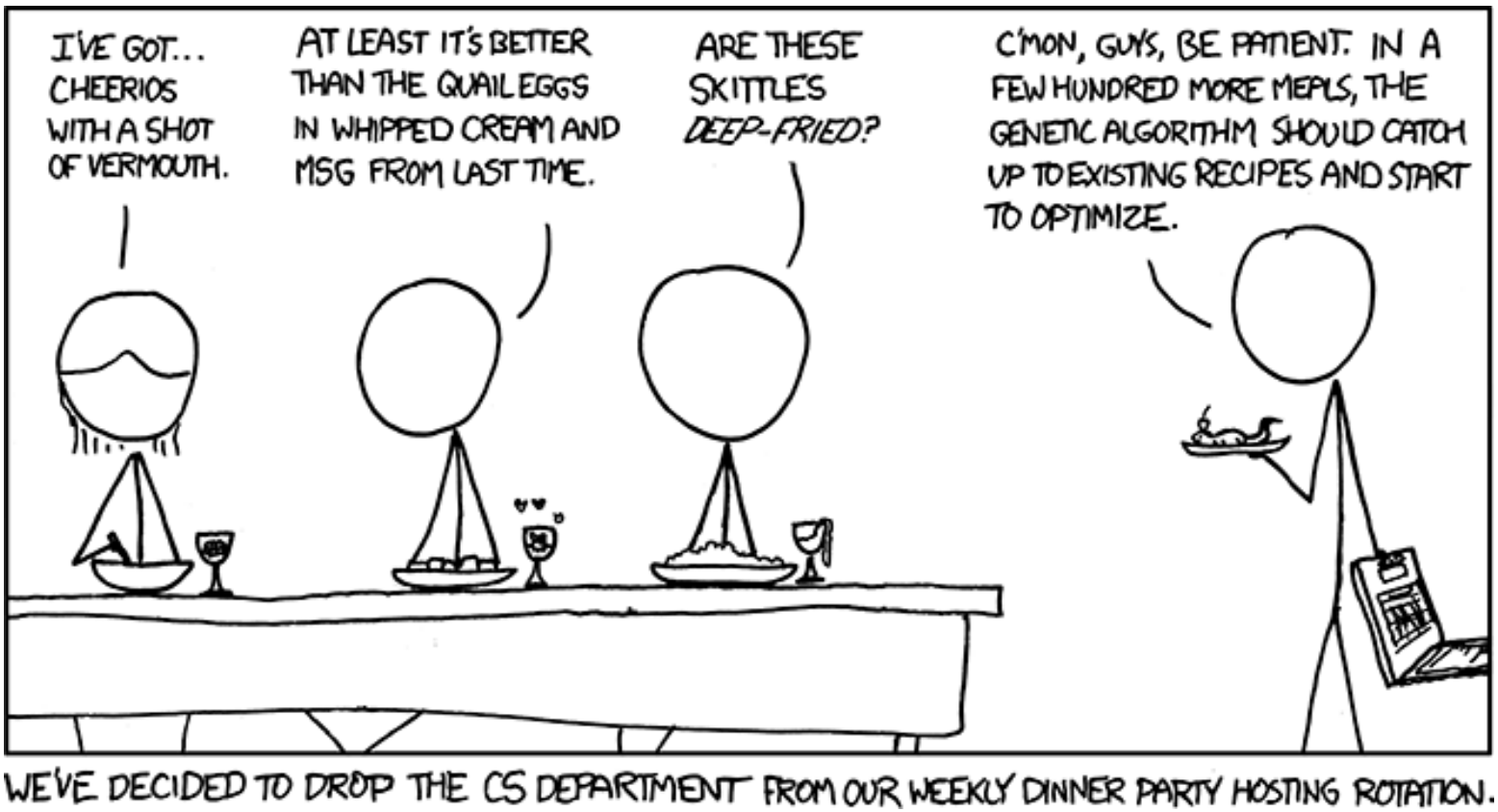


Image source: `http://xkcd.com/720/`