Academic Betadiversity and Future of Biological Collaboration

* Abstract
* Introduction:

Innovative discoveries often come from collaborations among from differing fields. The importance of cross-disciplinary work is a key goal highlighted by the National Science Foundation and the National Institutes of Health. The meeting of biological disciplines has spurred both theoretical and methodological progress. For example, the melding of quantitative genetics and evolutionary theory gave rise to the evolutionary biology’s modern syntheses, the growth of cell and microbiology tools is in part due to contributions of biochemistry, and the current omics age is fueled by a tremendous growth in bioinformatics. An ever-growing list of challenges, from the evolution of antibiotic resistance to ecosystem engineering requires scientists to embrace a wider view of life sciences.

Despite the critical importance of interdisciplinary work, it hard to assess the relative specialization and connections of biological disciplines. While many studies have focused on citation indexes as a proxy of academic success, there is a wider tidal shift that slowly drives academic fields together and apart. By studying the emergent properties of life-sciences as an interconnected and complex system, we can identify areas of collaboration among current teams and potential opportunities for future growth.

The emergence of network biology provides a rubric for visualizing and quantifying interdisciplinary research. Network biology harnesses graph theory to represent connections among group members, and has been used extensively in social sciences, anthropology, and in microbiology. Graph theory is a branch of discrete mathematics that quantifies interactions among members of a set, called nodes, by measuring connections, called links, based on an interaction currency. To visualize the totality of life sciences requires constructing an adjacency matrix where each academic discipline is compared to every other discipline. This matrix consists of the amount of niche overlap between disciplines, as measured by the abundance of articles published by authors in each discipline. The goal of this analysis was to determine, 1) Which fields are most insular? 2) How have the rates of collaboration changed among biological disciplines in the last fifteen years? 3) Where is there potential growth among disciplines?

Using the Scopus database I queried all articles from 2000-2015 for each of 700 journals which has been classified into XX biological disciplines (Table S1). Using the authors from these XXXXXX publications, I tallied the number of publications by each of 50,000 authors in each discipline. I measured the connectedness, betweeness and niche overlap of each field, which are three measures of centrality in graph networks. In addition, I calculated the change in link strength between disciplines over time to help visualize the shifting connections and affinities for biological collaboration. Finally, I performed a null-based model of link strength to evaluate which disciplines interact less than expected given their frequency of publication.

Results

Using the Scopus archives, I was able to classify XXXXX articles, from XXX journals consisting of XXXXXX authors. After discarding extremely weak links, the disciplines were ordered from most connected to least connected (Table 1). On average, disciplines were connected to X other disciplines, with an average link strength of XYZ. Overall, the network showed large modularity, with discrete compartments comprising X,Y,Z and X,Y,Z. Visualizing the network showed that these modules were connected by X,Y disciplines.

Overall, temporal patterns among reasonably connected disciplines were fairly static. The ten largest increases in connectivity all included X,Y,Z while the ten largest decreases in connectivity included X,Y,Z. The patterns of temporal change were largely robust to x,y,z. When publication records were randomized with respect to discipline, I found x,y,z.

* + Bridging of fields
    - Modern synthesis
  + Lack of quantitative data on collaboration
  + Network analysis
    - Measures of specialization
  + Aims
    - Which fields are most specialized?
    - Which collaborations have grown/decreased over time?
    - What fields tend to interact?
    - Which fields are forbidden links
      * Potential for future academic growth
* Methods
  + Scopus archives
  + Each classification consisted of twenty journals. While the boundaries of discrete classifications will always be difficult to define, the vast majority of journals can be placed between one or two categories.
  + Journal Classification
  + Defining Niche overlap
  + Search Terms
    - Temporal Search
  + Network statistics
  + Change through time
* Results
  + Specialization among fields
  + Collaboration among fields
  + Change over time
* Discussion
  + Academic networks and future for evaluation
  + Promoting collaboration and indexes through citation sharing (cites)
  + On why we see strong interaction among certain fields
  + Caveats
  + The potential for future growth