Collaboration Patterns in Model Organism Research: Co-authorship, acknowledgement, and the starlet sea anemone (*Nematostella vectensis*)

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BACKGROUND

Quantitative studies of scientific collaboration most commonly focus on co-author productivity and relationships (Cronin & Franks, 2006; Sonnenwald, 2007). Evidence of a less visible and thus less accessible level of research interaction can be found in the acknowledgments section of published research reports which Cronin (1995) described as "indicators of subauthorship." Most studies of acknowledgments have focused on classifying the type of acknowledgement in a detailed (see McCain, 1991) or aggregate (e.g., Cronin & Franks, 2006) scheme at the level of the discipline (often through their flagship journals such as *Genetics* and *Cell* in the life sciences). At this level of analysis, one can identify the relative frequency with which materials are exchanged, manuscripts commented on, and technical and/or financial support provided, but the breadth of the analysis is too great to bring out frequent connections and identify potential relationships between those who make and those who receive acknowledgements. The research reported here focuses on a more coherent body of authors and publications—the literature associated with research on a model organism. Model organisms such as fruitflies, zebrafish, mice, the fungus *Neurospora,* or the mustard *Arabidopsis* are small, easily obtained and maintained, reproduce rapidly and have genetic or other features useful for biological study. In this report, the animal of interest is *Nematostella vectensis* (the starlet sea anemone), whose value as a model organism was first proposed by Hand and Uhlinger in 1992.

OBJECTIVE

To explore two levels of collaboration in research focusing on a specific organism—co-author networks and acknowledgments of individuals and organizations contributing to the research—and to identify any strong connections/relationships between co-authors and those thanked for (non-financial) research support.

METHODS

For this first look at the research literature, I searched the scientific name, *Nematostella vectensis*, as a "topic" in the Web of Science. This retrieved all records with the name in standard metadata fields (title, abstract), the Author Keywords (included when available in the indexed article) and KeywordsPlus. This last field includes words and phrases frequently occurring in the titles of the Cited References and can be a source of noise in the retrieval. All records were inspected and articles reviewed if necessary to eliminate those not focusing on *N. vectensis* (e.g., faunal surveys, very broad literature reviews, articles not on *N. vectensis* but containing an *Nv*-related Cited Reference). Letters, editorials, book chapters and non-English language articles were also dropped. Three hundred eleven articles were retained for analysis.

Article metadata were ported to a Filemaker Pro database and acknowledgement and funding data added to the article records. Authors of meeting abstracts were included in the co-author analysis but not in the analysis of acknowledgements (since they lack this information). Co-author data were compiled and all author pairs with 2+ bylines were submitted to UCINet and Netdraw for analysis. The text of each journal article's acknowledgement section was parsed to separate the various statements (the existence of a funding statement was noted, but not the separate funding agencies). The non-funding-related statements were categorized using an acknowledgements classification scheme based on McCain (1991) and the names of all individuals and organizations tallied. The enhanced classification scheme (not shown, due to space constraints) added the provision of experimental animals and genome project data as Research-Related Information (Class 1) and animal husbandry in Technical Support (Class 4).

RESULTS
Figure 1 [attached] shows the growth of the *Nematostella vectensis* literature (journal articles and meeting abstracts) between 1991 and 2014 (the last year for which data were gathered). The co-author network analysis produced 16 separate co-author network components for authors with a minimum of two co-authored publications. The main component included 91 (67%) authors of the 136 authors, while the remaining components ranged in size from 2 to 9 authors, including 8 dyads. Figure 2 [attached] shows the main component. Node size is based on the number of direct connections (degree centrality) and link width is based on the number of bylines shared by the two authors. Authors connected with the laboratory heads as students, post-doctoral researchers or known to be in the same institution at the time of publication are color-coded: Martindale/lab = red, Finnerty/lab = green, Technau/lab = orange. Finnerty's own node is purple—he was a post-doc in Martindale's laboratory at the University of Hawai'i and then established his own research laboratory at Boston University. The strongest connections are among Martindale, Finnerty and former students/post-docs--Martindale & Pang (22), Finnerty & Reitzel (18), Martindale & Matus (17) and Finnerty & Sullivan (15). More than 500 individual authors, laboratories and research institutions were mentioned in the non-funding-related acknowledgments but only a few were mentioned frequently. Table 1 focuses on the tally of acknowledgments to the three main laboratories in Figure 2 (laboratory director and generic "thank the members of X's laboratory), distinguishing between acknowledgements from colleagues/students/post-docs, other authors in the main component and authors in other components. Acknowledgments of Cadet Hand (the "father" of *Nematostella vectensis* research) are included to highlight his influence in the field.

DISCUSSION
Focusing on *Nematostella vectensis* research and requiring at least 2 bylines between authors shows that this is a very coherent, interconnected research area with most of the strongest links occurring between authors who have additional social/institutional relationships. Having an inventory of *Nv*-related publications allowed me to go beyond simple counts and distributions of acknowledgement categories and those acknowledged by connecting the recipient(s) of a given acknowledgment statement with the source and with some identification of the relationship between source and recipient. Acknowledgments received by the three laboratory directors and their generic "labs" fall primarily into Class 1 (RRI) and Class 3 (Peer-Interactive Communication) and are largely from colleagues/post-docs/students. Martindale & his laboratory received more thanks for RRI (animals, materials, facility access and protocols) than did the other two laboratories and more acknowledgements came from authors outside of the main component network. Seven papers from the Martindale/Finnerty authors recognized Cadet Hand's role in bringing *Nemtostella vectensis* to biologists' attention as a valuable model organism.

NOTE: The results reported here are preliminary. At the suggestion of one reviewer, an expanded set of Nv-related documents is being collected. The analyses of collaboration/acknowledgement data in this expanded document set are underway and will be presented at the 2015 Workshop.

REFERENCES
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Cronin, B. & Franks, S. (2006). Trading cultures: Resource mobilization and service rendering in the life sciences as revealed in the journal article's paratext. *Journal of the American Society for Information Science & Technology, 57*(14): 1909-1918.
Hand, C. & Uhlinger, K.R. (1992). The culture, sexual and asexual reproduction, and growth of the sea anemone, *Nematostella vectensis. Biological Bulletin, 182*(2): 169-176
McCain, K.W. (1991). Communication, competition, and secrecy: The production and dissemination of research-related information in genetics. *Science, Technology & Human Values, 16*(4): 491-516.
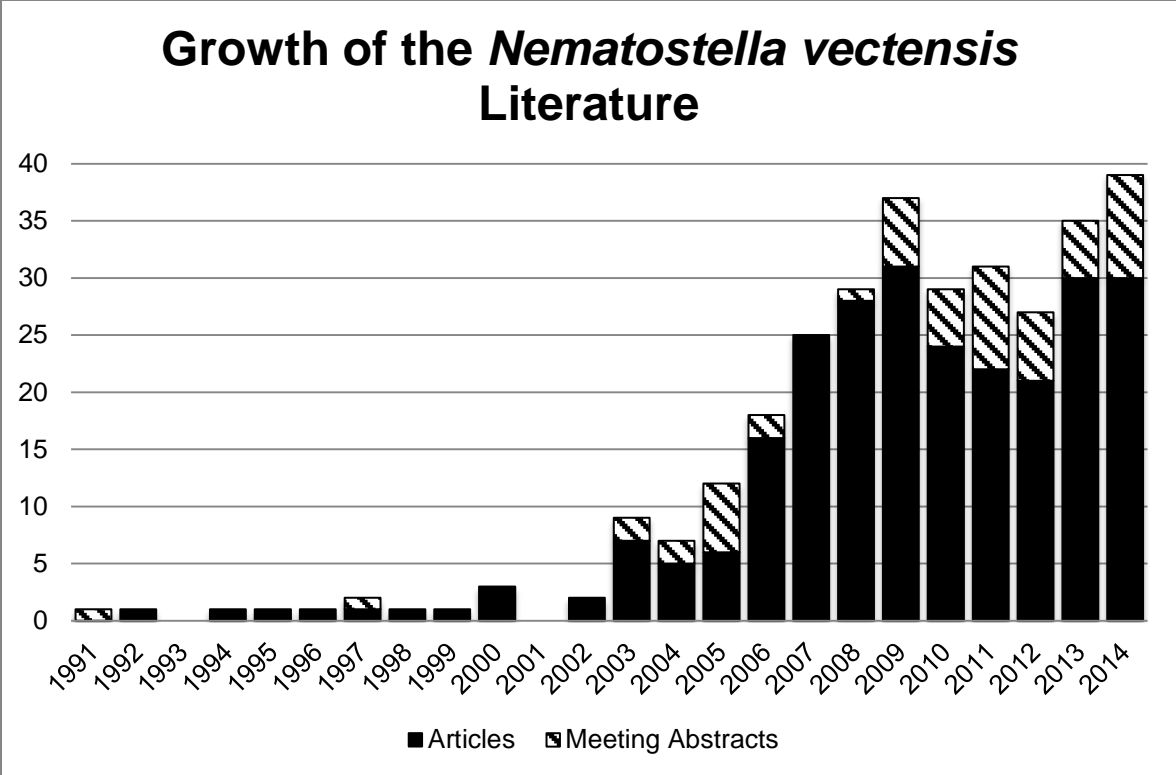Sonnenwald, D.H. (2007). Scientific collaboration. *Annual Review of Information Science & Technology, 41,* 643-681.

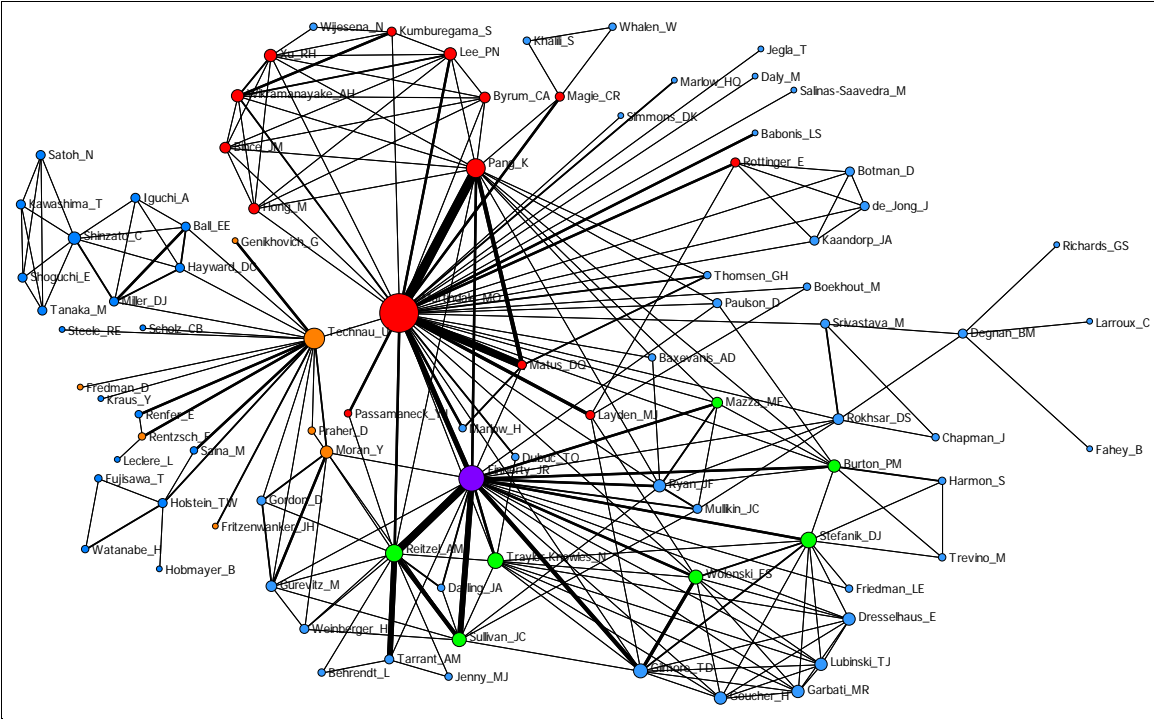**Figure 1**: Annual distribution of journal articles and meeting abstracts

Figure 2: *Nematostella vectensis* co-author network main component, 1991-2014. Minimum tie strength=2 co-authored papers. See text for explanation of color-coding.

Table 1: Distribution of acknowledgements to three key authors (Martindale, Finnerty, Technau), including generic acknowledgements to their laboratories, and acknowledgements to Cadet Hand, who first proposed *Nematostella vectensis* as a model organism.

	ACKNOWLEDGMENT RECIPIENTS												
	Martindale & lab			Finnerty & lab			Technau & lab				Cadet Hand		
ACKNOWLEDGMENT CLASS	C	N	O	C	N	O	C	N	O		M/F	T	Other
1a providing animals			1	1			1		1			1	2
1b providing clones, plasmids etc		1	3			1	2						
1c access to facilities	3			1									
1d unpublished protocols			4										
1f involvement in genome projects		1			1								
2a unpublished results				1			1						
3a providing specific information		1							1				
3b providing comments on MS	1		1										
3c providing general comments	2		1	1		1	1						
3d inspiration, valediction	2										7		
C = acknowledgments from colleagues, students, mentees													
N = acknowledgments from other authors in main component (see Figure 2)													
O = acknowledgements from other authors in other components													
M/F = acknowledgments from Martindale & Finnerty groups													
T = acknowledgments from Technau group													
Other = acknowledgments from other *Nematostella vectensis* authors, any component													