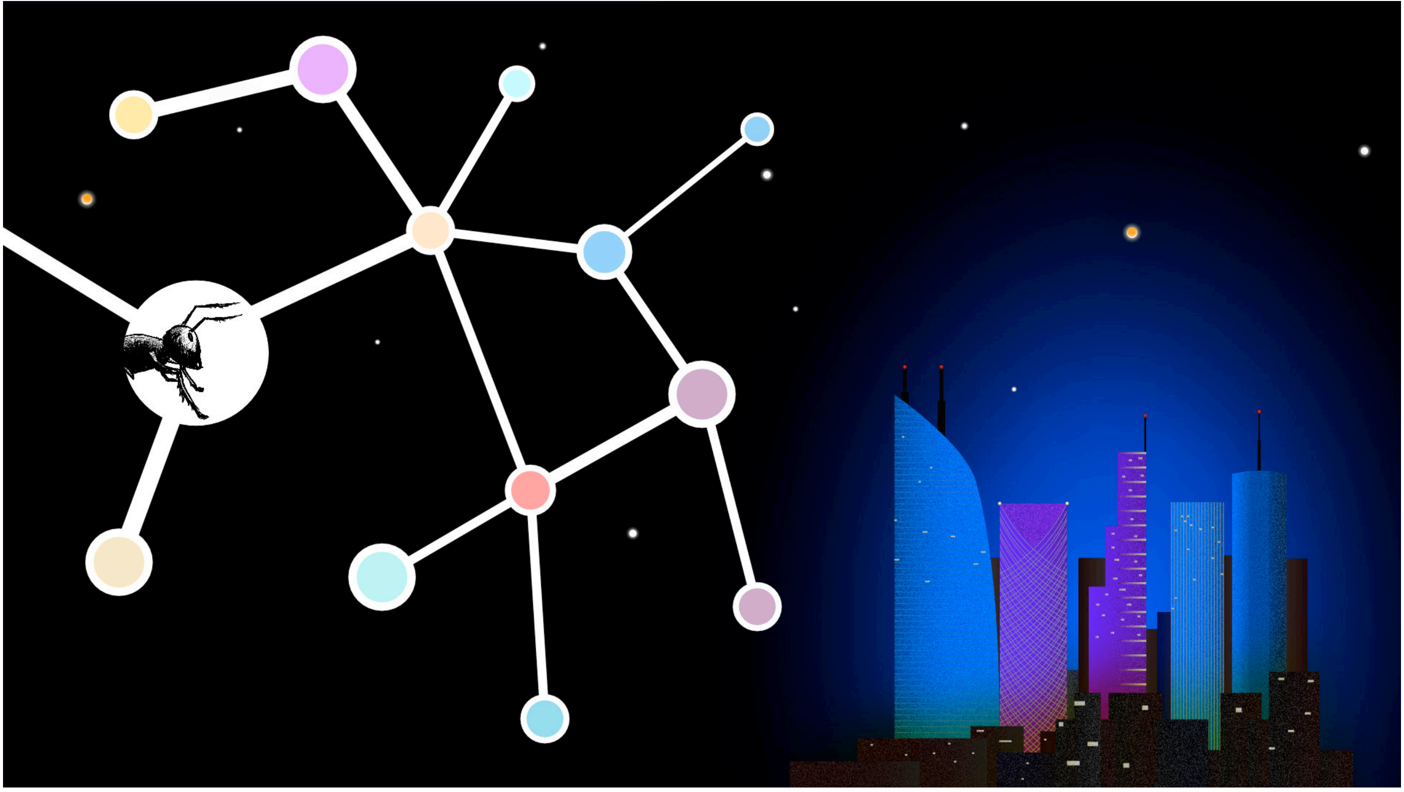


What animal societies say about ours

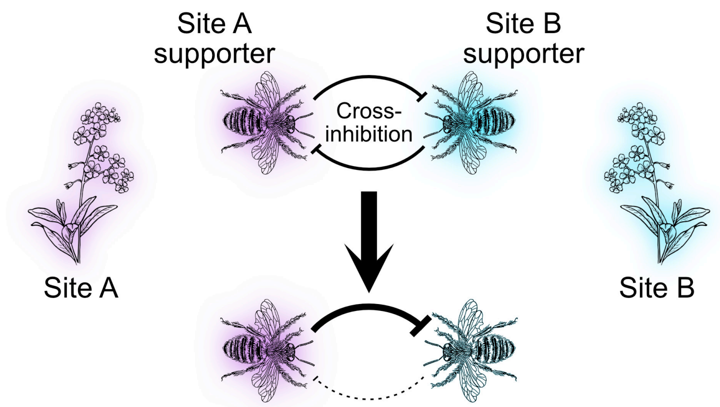
by Chris Tokita

When we think of the hallmarks of complex societies and civilization—agriculture, division of labor, architecture, language, and, in the modern era, even democracy—we often attribute these features only to humans. We tend to believe these achievements set us apart from other species and are a testament to our dominance on Earth. The story we often tell students is that "civilization" began approximately 5,000 years ago when simple human societies of hunter-gatherers gave way to more complex human groups that practiced agriculture.

But when we do so, we omit the fact that ant societies in the Amazon basin discovered agriculture some 50 million years earlier, transitioning from life as hunter-gatherers to fungus farmers and that there are countless other species living in complex societies rich with many of the same dynamics and properties we attribute to the pinnacle of human existence. Humans, after all, are animals and the dynamics that govern other animal societies do not suddenly stop at the doorstep of humanity . Therefore, a more ready exchange of ideas between the social and biological sciences will achieve a more complete understanding of social life.

The founders of sociology recognized the importance of looking beyond humans in order to understand society. Auguste Comte, who originally coined the term "sociology", argued that studying animal societies could yield hints of humanity's social nature. Fellow founder of the field, Emile Durkheim, drew from Darwin and biological parallels to argue for the "natural laws" of societal evolution that result in division of labor and economic specialization in humans. However, centuries later, biology and sociology remain separate disciplines and research that includes both is not the norm. In my work, I am seeking to bridge the gap between the two sciences through the use of computational modeling. Computational modeling allows me to ask "what if" scenarios: I simulate societies in which individuals follow a particular set of rules or behaviors, and I get to observe how those rules play out and affect group-level organization. Not only is this helpful in finding possible explanations for patterns we observe in societies, but it can also create new predictions to guide future work (e.g., if individuals all do X, we would expect to see Y).

To see how broadening the study of societies beyond humanity could bring new buzz to our understanding of societies, consider the species who Aristotle once declared joined humans in the realm of "political animals": the honeybee. Millennia later, more rigorous studies have revealed the sophisticated, and yes perhaps political, inner workings of a hive. Occasionally, honeybees must move their hive to a new location, which triggers a collective decision-making process. Scouts fly out from the colony in different directions in search of suitable new places for the hive. After locating a site, a scout returns to the hive and begins dancing in order tell others about the site. The angle of her dance tells others what angle they must fly from the hive to find the new site, the length of ground she takes to perform her dance tells them the distance they must fly, and the number of times she performs the dance tells how good of a site she thinks it is. Dancing scouts pique the interest of observing hivemates who go and see the site for themselves. Upon their return, if they also find the site to be suitable, they join the original scout in promoting this site through dance. This process typically continues for several days, as factions compete to win over "the votes" of undecided bees. Once there is only one faction left and the dancers are all performing in favor of one site, the colony flies together to the new location.



This form of unanimous direct democracy does not always work smoothly, however, providing a cautionary tale for democratic societies. Perhaps familiar to those living under modern American politics, sometimes two sites manage to gain equally sized, equally fervent groups of dancers arguing in their favor. This deadlock—or, in the parlance of political science, opinion polarization—among the group can have devastating consequences. Thomas Seeley, the Cornell biologist who is responsible for much of these fascinating observations of honeybees, once observed a hive so locked in indecision between two sites that it literally split into two separate groups that flew to two separate sites. Making matters worse, the queen was somehow lost in the chaotic separation of the colony factions. In losing the queen, who had the sole responsibility of producing new offspring for the hive, the colony lost its future too. After a fruitless search for the queen, the two opposing factions eventually dissolved entirely and scattered with the winds, thus ending the colony's existence all together.

Despite its grim description, the splitting of a hive is an extremely rare occurrence thanks to the social dynamics employed by the bees. Biologists have found that deadlock is avoided in hives because the individuals reporting in favor of a site frequently shift back to "undecided". This prevents bees from being locked in support for one site and instead ensures that all bees have more of a chance to switch their support over time. Why do bees drop their support for sites over time? The scouts reporting in favor of a specific site seek out scouts reporting in favor of other sites, and upon finding one, release a signal that causes their competitor to stop reporting that site—a process called cross-inhibition. Reflecting on our own modern democracies, such a process would be akin to supporters of a political candidate reaching out to supporters of another candidate and convincing them to drop their support (although not necessarily pick up the support of another candidate right away). This social dynamic ultimately prevents a society from reaching a deadlock of even sized fractions, as shown by the hundreds of thousands of years that bees have been using this dynamic to successfully make group decisions.

But just as animal societies can provide insights to our own social dynamics, insights from human society may be equally valuable to biology. For hundreds of years, the social sciences have been documenting social dynamics found in our species; perhaps it is time we consider whether some of these concepts might apply to the other complex societies on Earth. To illustrate this potential, consider ants, who typically live in large, impersonal societies of thousands of individuals. The first half of my dissertation used computational models to study how division of labor—specialization by individuals on certain tasks, such that they each fulfill the role of "forager" or "nurse", for example—emerges in collectives, particularly social insect colonies, purely through self-organization. Despite us labeling the egg layer of a colony "the queen", she actually exhibits no control over the workers in the colony. Instead, colonies are organized very democratically, typically with individuals following local cues to make decisions about what job they should do to help the colony.

I became interested in how social interactions between individuals might influence which tasks an individual ends up specializing in. In reading how other modelers have thought about how social interactions in groups, I came across a body of literature in the intersection of sociology and political sciences concerned with political polarization. Sociological modelers showed that if individuals tend to become similar in opinion to those they interact with and tend to interact with those who share similar opinions, a feedback loop forms that ultimately ends with the group split into two groups holding extreme and opposing opinions. Given that political polarization causes individuals to act predictably—e.g., only vote for one party or issue position—it seemed to be a potential behavioral parallel to division of labor, where individuals act predictably and by specializing on one or a few tasks.

We borrowed this general dynamic—a combination of social influence and bias towards interacting with those who are similar—and put it in a model of division of labor we knew explained ant behavior well. We found that this feedback loop caused division of labor to emerge, even when individuals were all initially identical, leading to individuals that became so specialized that they each only performed one task. What's more, "polarized" social networks emerged as a result of these social dynamics, such that individuals performing the same task all closely associated with each other and tended not to interact with those performing other tasks. This interaction pattern actually resembles what is really seen in ant social networks, and therefore the social dynamic we tested could help fill a gap in our understanding of how social network structure and division of labor are intertwined in social insect colonies. More broadly, however, our results suggested that political polarization and division of labor may be driven by the same process. Given how ubiquitous social interactions are in societies, this opens up the question of whether this same process may be organizing societies in other ways as well.

We should ultimately consider the exchange of ideas between biology and social science to be a two-way street, as there are still many more areas where the combination of both fields could unearth a wealth of new insights. Not only do ants and people have similar social networks, so too do dolphins, fish, chimps, and birds (where research shows individuals form cliques based on a range of factors including age, body size, and personality, among other traits). Could these animal social networks help us understand how we organize ourselves? Could sociology and psychology shed light on why animals may tend to associate with others like themselves? Elsewhere, a new field of study is beginning to explore how architecture and space influence the behavior of their inhabitants, with work spanning from examining office buildings to ant nests.

The current state of science—replete with the computing power to run complex behavioral simulations, algorithms to track the behavior of thousands of individuals at once in bee hives and the internet alike, and new ways to access research from outside our discipline—seems poised to offer a new era of collaboration among behavioral scientists. While the structure of the scientific enterprise may force us to more closely associate with those in the same field as us, I hope we find ways to reach across disciplinary boundaries. Ultimately, to find a common thread in the social life of not only all people, but all social species on Earth, we will need to see the bigger picture.

Chris Tokita is a Ph.D. candidate in the Department of Ecology & Evolutionary Biology at Princeton University. A computational biologist by training, his research uses computer simulations to explore how collective behavior and social network structure emerge in societies—from ants to people. A native of Los Angeles, Chris spent two years working in Federal science policy in Washington DC before entering graduate school.