Theorizing Networks in World History

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The study and teaching of world history give priority to viewing the past at multiple scales. Most examinations of world history focus temporally on the last few centuries and on the largest structures within that time, with historians conducting their analyses in the context of a longer-term story of human transformations. In simplified terminology, I distinguish the "grand narrative" of long-term history from the "sub-global analyses" which, even if they are huge and multivariate studies, can be set in context of the longer-term story. In recent times, world-historical studies have extended the grand-scale narrative back in time to roughly 100,000 years ago. As a consequence, world historical research and interpretation are transforming at sub-global scales.[1]

In the past century of world-historical studies, the grand narrative has undergone at least two such transformations. An inherited civilizational narrative, centering on literate Eurasian societies of the past 5,000 years, treated life in earlier times and other lands as "prehistory."[2] This view was supplemented and then superseded, in years after 1950, by a narrative of the past 10,000 years that began with the rise of agriculture. Prehistory was displaced to times before agriculture and to the lives of "hunter-gatherers," while world-historical studies of more recent times turned to comparative studies.[3] Then, in response to the advances in genetics, paleontology, archaeology, and linguistics after 1980, the grand-scale narrative of world history has expanded—reaching almost as far back as 100,000 years ago to the time of the *Homo sapien* global expansion.[4]

Successive generations of scholars, in extending this grand narrative, have had to address not just expanded periodization but also new scales and gradations in historiography. Each additional historical terrain—once annexed into the study of world history—needs to be incorporated through steadily more detailed analysis, while the pre-existing domains of world history need to adjust their relations. Prehistory, rather than be eliminated, has been displaced to earlier times by each expansion of the historical narrative, so that it now centers on the millennia before 100,000 years ago. Interestingly, confirmation of the African origin of *Homo sapiens* (some 300,000 years ago) has shifted all later narratives of human history—yet human emergence itself is still left in the mists of prehistory, perhaps to be incorporated through some later expansion of the narrative.[5]

This essay treats network analysis as a necessary element of the expanding scope of the world historical narrative and methodological diversification. The essay begins by distinguishing narrative, dynamics, and context as interacting elements of global historiography, showing networks as an aspect of this interaction. The four sections of the body of the essay go on to present the elements and dynamics of several categories of networks; the overlaps of networks with such other analytical categories as groups and institutions; Robin Dunbar's influential analysis of groups and networks of humans and other primate species; and applications of network thinking to major dynamics in world history. In sum, the essay argues that networks, more than a metaphor for human interconnection, provide a valuable tool for historical analysis.

[1] R. Charles Weller, ed., 21st-Century Narratives of World History: Global and Multidisciplinary Perspectives (Cham: Palgrave Macmillan, 2017).
[2] H. G. Wells, The Outline of History (1920), was unusual in doing the best that could be done, at the time, to survey human history and Big History as well as civilizational history.
[3] William H. McNeill, The Rise of the West: A History of the Human Community, (Chicago: University of Chicago Press, 1963).
[4] A further scale of context arose with Big History, which set human society in the context of the natural world and its evolution David Christian, Maps of Time: An Introduction to Big History (Berkeley: University of California Press, 2003).
[5] Rebecca L. Cann, Rebecca L., Mark Stoneking, and Allan C. Wilson.\, "Mitochondrial DNA and Human Evolution," Nature 325 (1987): 31–36.

Narrative, dynamics, and context in long-term world history

In an important 2003 update in the interpretation of world history, J. R. McNeill and William H. McNeill (son and father) published *The Human Web: A Bird's Eye View of Human History*.[6] The subject of the book, as the authors stated, is ". . . how people created the webs of interaction, how those webs grew, what shapes they took in different parts of the world, how they combined in recent times into a single cosmopolitan web, and how this altered the human role on earth" (p. 8).

The *Human Web* begins by invoking individual human agency: "What drives history is the human ambition to alter one's condition to match one's hopes." In addition, at times, the McNeills attribute a sort of agency to webs: "Thus, webs channeled and coordinated everyday human ambition and action—and still do." The book presents webs at various levels, each entailing human cooperation, competition, and growth. They define the human web as "a set of connections among people," dating "at least to the development of human speech," although "over time the human web changed its nature and meaning so much that we will speak of webs in the plural."[7] Webs are described as combining cooperation and competition, but especially communication that sustains cooperation. In an underlying dynamic, those groups that "achieved more efficient communication and cooperation within their own ranks improved their competitive position and survival chances." Perhaps as a result, the scale of webs tended to grow. "The power of human communication, cooperation, and competition shaped the earth's history as well as human history."[8]

As the book goes on, however, agency and dynamics move to the background, while the foreground is occupied by summary characterizations of succeeding eras and regions, often phrased in a passive mode. "By about two millennia after their emergence, agricultural villages had spread like a rash across Eurasia, Africa, and the Americas and became the frame within which the majority of humankind lived and died. . . . Sedentary villages replaced roving bands of hunters and gatherers as the basic cells of human society. . . . But such villages were also embedded in a far-flung web, denser than before, yet still very slender in comparison with what was to follow ."[9]

The authors, in addressing the immensity of human history, apparently found it best to highlight sequential narratives, setting into the background the unresolved problems, debates, and choices. As they describe successive patterns of human life over time and space, webs serve as expository devices rather than as active agents.[10] The opening pages portray a bottom-up effort to trace the agency of humans in interaction with their surrounding conditions, as humans transformed themselves and their world. Later pages, however, convey a top-down sequence, leaving readers to view the dioramas of each period, in which the scale expands from scene to scene while the images are static. The narrative acknowledges disaster and destruction along the way, but these too move to the background. If small-scale social units were linked to the massive webs, the reader does not see how this was the case.[11]

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[6] J. R. McNeill and William H. McNeill, The Human Web: A Bird's Eye View of World History (New York: Northrup, 2003).
[7] McNeill and McNeill, Human Web, 3–4. It has also been followed up with a two-volume introductory textbook in world history, with a narrative organized according to the same principles J. R. McNeill, The Webs of Humankind: A World History, 2 vols. (New York: Norton, 2020).
[8] McNeill and McNeill, Human Web, 5–7.
[9] McNeill and McNeill, Human Web, 39.
[10] I emphasize that I found value in following the McNeills' lead with an interpretation of the "African Web" as an ancient network of communication and exchange within Africa. Patrick Manning, The African Diaspora: A History through Culture (New York: Columbia, 2009), 40, 51. For a deeper yet highly accessible exploration of the networks of life in the southern half of Africa, see Catherine Cymone Fourshey, Rhonda Gonzales, and Christine Saidi, Bantu Africa: 3500 BCE to Present (New York: Oxford University Press, 2017).
[11] Nevertheless, the same J. R. McNeill is also co-author of a challenging analysis of accelerating environmental crisis since 1945. J. R. McNeill and Peter Engelke, The Great Acceleration: An Environmental History of the Anthropocene since 1945 (Cambridge, MA: Belknap Press of Harvard University Press, 2014).

Nearly a decade later, in 2011, *Sapiens* appeared as another concise grand narrative in world history. Author Yuval Noah Harari was more argumentative than the McNeills, relying more visibly on the scientific literature. Yet this volume too is mostly narrative. Its main explanatory devices, in place of a spatial web, are in theory of the mind—Harari's hypothesized Cognitive Revolution and the resulting "imaginative thinking." But these two elements are not backed up either with dynamics or context. [12]

In each of these cases, the narrative takes for granted many of the fundamental transitions in history. That is, the big changes are mentioned but not questioned or analyzed in detail. The rise of language, the formation of social institutions, the global migration of humans, the expanding scale of social groups, the logic of philosophy and culture—all are noted in relatively smooth order and then recede to the background. The great strength of narratives is that they keep in view the Human System as a whole, enabling one to ask where any topic or debate fits within the overall picture. But is there a way to alternate and balance top-down and bottom-up approaches to the past? My purpose is not to challenge the value of these grand narratives (I rely on them and consult each of them frequently.), but to distinguish their limits from their achievements and to propose next steps in the analysis and portrayal of grand-scale world history.

Narratives are necessary but not sufficient for conveying the logic of history. They give readers an authorized story to recite, but not a set of challenging problems to investigate. This is one reason why world history has been slow to thrive as a field. As an additional constraint, the Human System has so many topics and subtopics—so many problems in documentation, terminology, and dynamics—that it is inherently difficult to conceptualize. The narrative strategy has the strength of being able to point to many different issues, but it is not strong in resolving the questions. World history will thrive as a field only when it can involve its students—be they research scholars or introductory students—in passionate debate and exploration of those big questions.

Theses on historical dynamics—context for their evaluation

I argue that it is now time to prioritize a problem-oriented approach to world history—especially for times before 5,000 years ago, yet also to link all the eras of world history. I have been developing and defending several theses on world-historical dynamics, arguing that they clarify important historical changes.[13] They correspond to a conscious attempt to balance bottom-up and top-down approaches to the dynamics of world history. I argue that historians should take the lead in addressing some of the major historical transitions that are taken for granted, beginning with the rise of syntactic language. I have also sought to join with others in linking human history to the biological studies of paleontology and genetics, and to archaeology and anthropology.

One major point of this essay, however, is to acknowledge that posing world-historical theses is fraught with difficulties. In developing each thesis, I encountered substantial difficulties, both endogenous and exogenous to the thesis itself, that complicate its analysis. The endogenous difficulties arise from the *dynamics* of the thesis—the process of inventing language, for example. The exogenous difficulties arise from the *context* or boundary conditions of the thesis—for instance, how characteristics of social groups affect the invention and spread of language. What I have found, therefore, is that developing a world-historical hypothesis involves paired modes of research: drilling down into the endogenous *dynamics* of the issue at hand, but also exploring widely to seek out exogenous *context* that might facilitate or constrain the dynamic under study.[14]

[12] Yuval Noah Harari, Sapiens: A Brief History of Humanity (New York: Harper, 2015). For a remarkable critique of the creation and impact of that book, see Mauricio Meglioli, La Increible Historia de "Sapiens" (San Juan, Argentina: Rogelio, 2021).
[13] Patrick Manning, A History of Humanity: The Evolution of the Human System (Cambridge: Cambridge University Press).
[14] At one level, this is a restatement of the need for both background and focused research on an issue.

As I began research and writing on the Human System, I sought background on systems logic, on biology, on environmental change, and I continued my reading on migration and language distribution.[15] Out of that work I developed three world-historical hypotheses:

1. Language arose by conscious development within a community.[16]
2. Institutions (formal social structures created to complete specific tasks) formed through collaborative group behavior.[17]
3. Cross-community migrations linked communities and generated knowledge.[18]

In *History of Humanity*, I made a general statement of the three theses, provided discussion of several topics of context, and wrote a narrative relying on those dynamics. The hypotheses seemed plausible to me at first, but I gradually found challenges within each of them, at both endogenous and exogenous levels. Indeed, it was the experience of facing these challenges that led me to formulate the distinction, which I make central here, between the dynamics and the context of each thesis. For language, the endogenous issues were in how the founding community of children was able to gather and sustain itself long enough to generate a functioning language. But the exogenous issue was the question of what preceded language: humans clearly had capacities for vocalization and communication before syntactic language, but did they have a "protolanguage" consisting of a small vocabulary of isolated words that was important in basic communication? Or, was prior communication focused on other media? For social institutions, the endogenous issue was not just the functioning of institutions but their reproduction and evaluation. The exogenous issue—the one that is the principal emphasis of this essay—was how informal networks overlapped with formal institutions.

Further, I encountered unexpected links among my theses. First, it became clear that the issues of language and institutions were neither separate nor separable. Syntactic language requires a conscious community sharing speech, so that language was the first institution. The experience of founding a speech community provided the lessons in institutional functioning—initially leading to advanced communication—that could then be applied to forming groups for other purposes. Thus, I had to redefine the boundaries of the endogenous and the exogenous, to account the context of networks in both institutions and language. Second, I came to realize that cross-community migration was not only a consequence of language emergence but an essential component of language emergence: syntactic language could only advance if a steadily larger number of people were recruited into the speaking community. Thus, the successful recruitment of non-speakers into speaking communities was just the first step in the much larger out-migration of speaking humans who settled Africa and the world.

In short, fundamental complications arose in the application of my initial theses. The theses themselves are not enough for explanation; they require a return to the drawing board for broader reconsideration.[19] While that review is laborious, at best it elicits stronger theses in fuller context. Such a contextual study may even unearth new and valuable theses on related topics.[20] The present study—one step in a larger process of review—explores the context of networks and network analysis, as it can be related to issues in world history.[21]

[15] Manning, History of Humanity, 52–57.
[16] Patrick Manning, "The Origins of Social Evolution: Language and Institutional Evolution," Anthropos (forthcoming). This study drew significantly on studies by linguists Joseph Greenberg, Christopher Ehret, Noam Chomsky, and W. Tecumseh Fitch.
[17] Manning, History of Humanity, 44–52.
[18] Patrick Manning, "Migration in World History," in Elli Heikkilä, ed., In Which Direction is Finland Evolving? The Dynamics of Mobility and Migration, 18–39 (Turku: Migration Institute of Finland, 2020).
[19] Such reviews should be undertaken for other world-historical hypotheses. An outstanding case is the various arguments for a single-cause impact of violence in human history developed by Douglass C. North, Steven Pinker, Walter Scheidel, and others.
[20] In particular, in exploring the context of social groups and networks, I found the human household to provide an unexpected but significant dynamic. See "Three Processes of Evolution in Households" (2022) at patrickmanningworldhistorian.com.
[21] The broader review, as I envision it, includes studies on the thesis of institutional evolution, on the context of cultural change, and the context of environmental change. See patrickmanningworldhistorian.com.

Networks—elements and dynamics

As I sought out introductory overviews of networks, I encountered a remarkable 2002 MA paper, in which geographer Anna Versluis prepared a comprehensive survey of network concepts and research in natural and social science disciplines. Unpublished but available online, it provides an excellent introduction to terminology and approaches.[22] As the author notes in her introduction,

> In engineering networks are used to model electrical circuits. In anatomy the circulatory system is described as a network. Molecular biology considers metabolic networks. Artificial intelligence employs neural networks. Computer science has various computer networks. City planning has road networks, water networks and electric grids. Geology has faults and fissures that create networks. Ecology has food webs. Mathematics has graph theory and branching processes. Geomorphology has stream and ridge networks. . .

Basic terms and distinctions

Versluis introduces a "standard terminology," applicable to most two-dimensional or *planar networks*. These terms are mostly descriptive of the *topology* of networks—that is, the geometry of position or the arrangement of elements in a structured space.[23] To begin, network structures have two basic components, defined according to two terminologies: *nodes* and the *links* between the nodes; or *edges* and the *vertices* where the edges meet.[24] "Nodes and links" are terms used in social network analysis, where nodes are prioritized and treated as separate entities with relationships to each other as defined by the links. "Edges and vertices" are used, for instance, in the study of streams and tributaries: edges meet at a vertex, and where they join is the main channel.

A network may be *directed* (its edges have a direction); it may contain *paths* (a sequence of no repeated edges or vertices). A *circuit* (or *cycle* for directed graphs) is a path where vertices are distinct except for the first and last. The *degree* or *valence* of a network is the number of edges a vertex has; and *connectivity* is a property of a network if every vertex is joined by at least one path. A *tree* or branching network is a network that contains no circuits. *Cells* make up areal networks of polygons. Networks may contain *loops* if both endpoints of one edge are the same vertex. Two categories of hierarchical networks exist: a *branching hierarchy* (with a root or terminus) and a *nested hierarchy* (with nodes containing networks). Stream systems and evolutionary phyla can be presented as branching hierarchies; food webs and transportation systems can be modeled as nested hierarchies.[25] These terms are used in the description of simple networks; they are also used to describe the basic characteristics of more complex networks.

[22] Anna J. Versluis, "A Review and Assessment of Network Concepts and their Applications in Geography and Related Disciplines," M.S. thesis, Oregon State University, 2002. While there have been important developments in network analysis since 2002, this essay is highly effective as a survey of network principles. The fields reviewed are mathematics, the "complex networks" of vascular networks and small world networks, sociology, engineering, geomorphology, evolution, and ecology. I have slightly revised her list of terms; where Versluis uses the term "graph," I have mostly replaced it with "network." There is more: my summary addresses about half of her sections.

[23] For details, see the section below on "Overlaps: networks and other structures."

[24] Nevertheless, the two terminologies may be mixed to yield "nodes and edges."

[25] Versluis, "Network Concepts," 10–11.

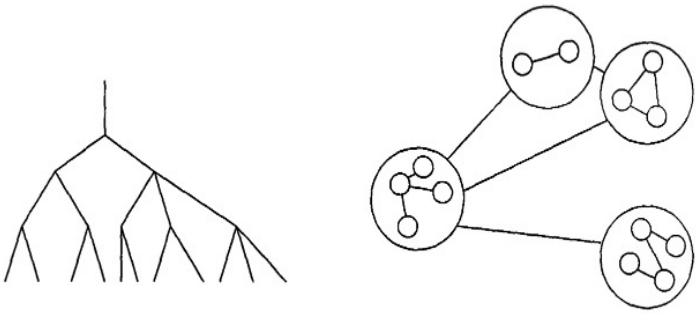

Figure 1. Hierarchical networks: branching hierarchy (left); nested hierarchy (right). (From Versluis.)

Complex static networks, especially small-world networks

Beyond these basic networks and standard terms, a range of *complex networks* has been developed and studied.[26] Here we will discuss regular networks, random networks, small-world networks, scale-free networks, generalized random graphs, and vascular networks. Regular networks and random networks are easiest to model and analyze, so they received initial attention. As Versluis notes, "Models of complex network topology tend to assume one of two extremes: either a network has completely random connection topology or completely regular connection topology."[27] Figure 2 shows examples of each type: on the left are a rectilinear lattice and a ring lattice, both of which share the property of being completely regular. On the right is a random network, in which the edges are added at random.

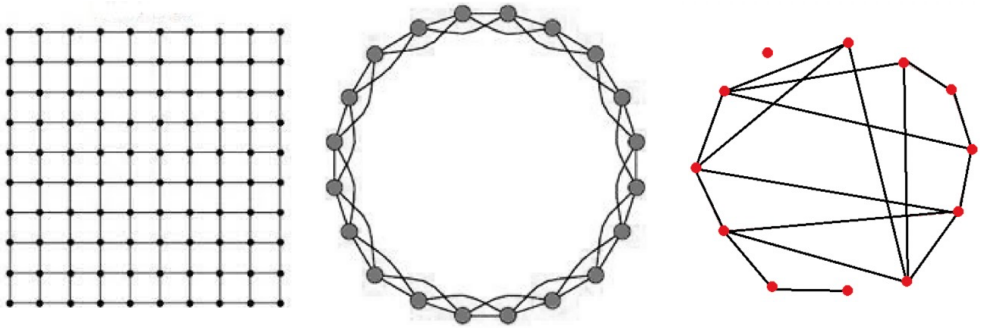

Figure 2. Regular or lattice network at far left; regular ring lattice at left; random network at right.

Some parameters or characteristic values arose for these networks. The *diameter* of a network, ***L*,** is defined as the shortest distance between the two most distant nodes in the network (more precisely, the maximum shortest paths between any two nodes in the network). The *clustering coefficient*, ***C*,** is defined as the average of the ratio of connected nearest neighbors to all nearest neighbors, or "cliquishness" of a typical subset of a network. Diameter is a global network property and clustering coefficient is a local property (though it may be averaged for the full network).

Watts and Strogatz explored the "murky middle ground" (between the extremes of highly clustered regular networks and poorly clustered random networks) by simulating networks of varying degrees of

[26] Initial level of complexity here—nonlinear dynamics is a more complex approach. Following the work of Strogatz, Versluis explores the issues of connection diversity (i.e., links between vertices may have direction or be inhibitory or excitatory); dynamical complexity (nodes may be nonlinear dynamical systems); and node diversity; plus combinations of these. Versluis, "Network Concepts," 16–17; S. H. Strogatz, "Exploring complex networks," Nature 410 (2001): 268–276.
[27] Versluis, "Network Concepts," 20.

randomness.[28] They looked at the two network properties noted above: network diameter, ***L,*** and the clustering coefficient, ***C,*** the average of the ratio of connected nearest neighbors to all nearest neighbors, or "cliquishness" of a typical subset of a network. ***L*** is a global network property; ***C*** is a local property. Regular networks (lattices) are highly clustered, and their diameter grows linearly with the addition of nodes. Random networks are poorly clustered and their diameter grows logarithmically (that is, more slowly) with the addition of nodes. To quote Versluis, "What Watts and Strogatz (1998) found on the continuum between random graphs and regular lattices are 'small-world networks' that are highly clustered like regular lattices yet have small diameters like random graphs."[29]

Figure 3 shows the approximate domain of "small-world networks" within the range of network architecture, where regular networks are at left and random networks are at right. As one calculates successive networks and their characteristics (moving from left to right by adding random nodes to regular networks), network diameter *L* drops rapidly due to the addition of a few random long-range edges while *C* stays almost constant. This suggests that the transition from a regular network to a small-world network is barely discernible at the local level."[30] Figure 4 illustrates a small-world network and its parameters, placed between examples of the polar limits of a regular ring lattice and a random network.

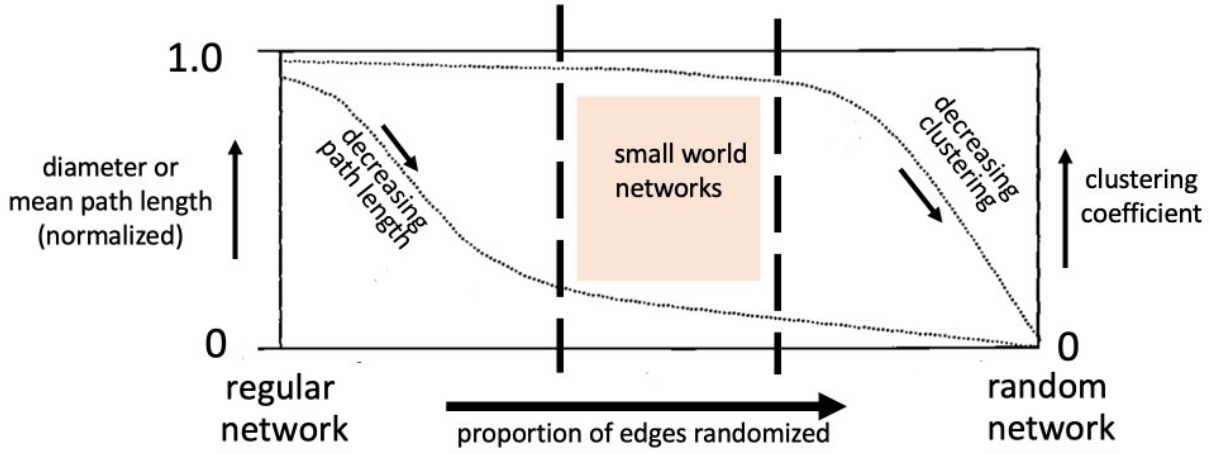

Figure 3. Identifying small-world networks in the context of regular and random networks.
(Revised from Versluis.)

[28] D. J. Watts and S. H. Strogatz, "Collective dynamics of 'small-world' networks," Nature 393 (1998): 440–442.
[29] Versluis, "Network Concepts," 21.
[30] Versluis, "Network Concepts," 22. For an elegant demonstration of this process with an applet, see D. Q. Nykamp, "Small world networks," Math Insight. https://mathinsight.org/small_world_network .

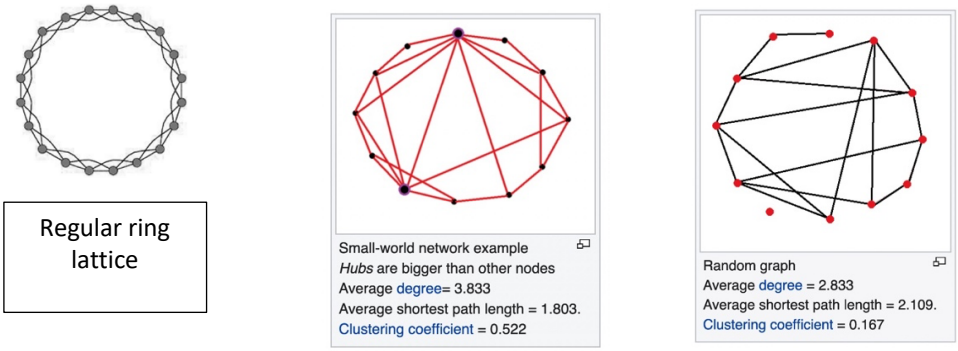

Figure 4. Regular, small world, and random networks. (From Wikipedia)

Pursuing this reasoning, Barabási and Albert found that in many large networks, vertex connectivity actually follows a scale-free power-law distribution where—in agreement with small-world networks—highly connected nodes dominate connectivity.[31] They successfully applied this power-law distribution to cases as film actor collaborations and the Web. Further work has suggested that there are several classes of behavior for small-world networks, with varying specific characteristics. This work has reinforced the 1998 suggestion of Watts and Strogatz that small-world networks are widespread in the natural world and the technological world.[32] Such a high level of self-organization in diverse networks (meaning that an overall order arises from local interactions between parts of an initially disordered system) is caused by two feature of small-world models: their growth and their preferential attachment—in which new vertices tend to attach to highly connected vertices.

An important application of the logic of small-world networks is in the navigation of networks even when knowledge is limited. Based on years of discussions, Stanley Milgram led a late-1960s experiment in which individuals throughout the U.S. were asked to mail letters to a target person in Boston by sending each letter to an acquaintance who in turn would forward it to another acquaintance Of the letters that reached their final destination, the average number of times the letter was forwarded was around six.[33] In 2000, Kleinberg showed that a small-world model could predict this behavior: it is possible to navigate a small-world network with only local information if the right level of clustering is present.[34] A 2002 study labeled this navigation property as searchability and proposed a model assuming that individuals have two types of partial information—on social distance and on network paths—that can combine to send a message through a social network even if they do not know the overall network structure.[35]

In another example of the interplay of empirical observations with network modeling, *vascular networks* (such as the flow of fluids within a body) came to be treated as networks. Biological studies had shown relationships between an organism's body mass and its physiology—for instance, the "quarter-power"

[31] A.-L. Barábasi and R. Albert, "Emergence of scaling in random networks," Science 286 (1999): 509–512.
[32] Versluis, "Network Concepts," 22–25. The definition has been rephrased somewhat over time. Wikipedia now defines a small-world network as, " a network where the typical distance L between two randomly chosen nodes grows proportionally to the logarithm of the number of nodes N in the network, while the clustering coefficient is not small."
[33] Versluis, "Network Concepts," 25–26; J. Travers and S. Milgram, "An experimental study of the small world problem," Sociometry 32 (1969): 425–443; Wikipedia, "Small-world experiment." Perhaps through some linkage, Walt Disney and Pepsi presented a 1964 exhibit, "It's a small world," at the 1964. New York World's Fair. The related term "six degrees of separation" appears to have been coined in John Guare's play of that name, which premiered in 1990.
[34] J. M. Kleinberg, "Navigation in a small world," Nature 406 (2000): 845.
[35] D. J. Watts, P. S. Dodds, and M. E. Newman, "Identity and search in social networks," Science 296 (2002): 1302–1305.

relationship, in which the life span of an organism is correlated the ¼ power of the body mass. Network theorists sought to create models that reproduced this and other such relationships between organism body size and physiology, such as the empirical finding that metabolic rate of an organism is proportional to the ¾ power of body mass.[36]

Social networks in cultural context

Social networks have become a substantial subfield within network analysis. Sociologist Paul McLean's 2017 book introduces networks to an audience of sociologists, then shows the use of networks in the sociology of culture. As he argues, "when starting with an interest in culture—that is, processes of meaning-making, identity formation, and communication using existing practices and symbols—thinking in network terms can help us to understand with more precision where and how new cultural ideas arise, how they are disseminated, where they collect, and why they might be unevenly distributed in society."[37] He focuses on "diverse analytical *intersections* of culture and networks: that is, various ways the analysis of social networks and the analysis of culture can be brought together." He continues, presenting social networks as part of a "relational sociology" that provides advances over conventional sociology, where "social structure" at the macro level and "individual preferences" at the micro level "are concepts too rigid to account for the variation we observe in social life on a constant and ongoing basis."[38]

Introducing networks in his second chapter, McLean presents the terminology of *nodes* and *links* in networks but replaces these terms for the most part with the terms *actors* and *ties.* Actors are entities forming nodes—they may be individuals, collectives, companies, or states. Links of nodes—or ties of actors—are relationships (kinship, money transfer, friendship, communication); McLean emphasizes the many ways to define such ties, notably the distinction between *weak ties* and strong ties, articulated by Mark Granovetter.[39] Then he turns to *Ego-networks*, which center on the perspective of a focal actor and relationships to others with whom he/she is tied. The standard terms for ego-networks begin with the *dyad*—any pair of nodes in a network, but especially if they are linked directly. The tie in a dyad may be *directed* (as in transmission of knowledge) or *undirected* (as neighbors); it may be *symmetrical* or *reciprocal*. *Homophily*, the similarity of actors to one another; is usually presumed to be a preference for actors in their ties. *Triads* are the level of connection where social structure begins to exist independently of individuals, and independent of the dyadic relations they work out between themselves. With triads, the relationship between any two nodes is potentially affected by the existence of other nodes and by the presence of ties flowing to and from those nodes.

Relying on the definitions above, McLean turns in his third chapter to addressing issues in larger network structures. The *structure* is the pattern the network takes on, impacting the functioning of actors and the whole network. It allows for existence of properties characteristic of the entire network or to some elements of the network, such as *cohesive subgroups* (emphasizing the parallel analysis of networks and of groups) and *reachability* (the same as *searchability* for Versluis), in which weak ties are important in transmitting information transmission. McLean argues that cohesive subgroups and reachability combine in the concept of the small world. "Small worlds permit local interaction to produce fruitful fermentation of ideas and creative cultural output, combined with the capacity to spread those ideas to other 'worlds' fairly quickly."[40] *Hierarchy* is noted as a complex issue. On *centrality* of nodes, "some nodes may be said to be more *central* than others—either because they have a lot of edges running directly to or from them (a high *degree*) or because it takes them especially few steps to reach many

[36] For further details on vascular networks, see Versluis, "Network Concepts," 17–20. West et al. used Euclidean geometry for the external body and a fractal geometry for the internal structure of the circulatory network. G. B. West, J. H. Brown, and B. J. Enquist, "A generalmodel of the origin of allometricscaling laws in biology," Science 276 (1997): 122–126.
[37] Paul McLean, Culture in Networks (Cambridge: Polity Press, 2017), 4.
[38] McLean, Culture in Networks, 7. Versluis made a similar point, "As should be evident, social network analysis was developed in part as an alternative to individualistic, reductionist, deterministic approaches to sociology."" "Network Concepts," 15-16.
[39] Mark S. Granovetter, "The Strength of Weak Ties," American Journal of Sociology 78 (1973): 1360–1380; McLean, Culture in Networks, 15–19..
[40] McLean, Culture in Networks, 29.

other nodes in the network, or because they lie on paths *between* many nodes, or because they are connected to other powerful or high-status nodes like themselves."[41]

The body of McLean's book explores ways to link networks and culture. McLean argues that networks provide the hardware (circuitry) of this relationship, while culture is the software (the rules and routines).[42] He emphasizes that, since the cultural turn in many fields of study, culture is seen as autonomous, not just derived from social, so that analysts must seek to use the mechanics of networks without being mechanical with culture. One must seek to see where cultural ideas arise, how they are disseminated, where they collect, and why they are unevenly distributed—by tracing the *intersections* of culture and networks. In the *practices* and *repertoires* of culture, McLean treats culture as a toolkit to be used in several approaches, which alternate in treating culture as *norms* (beliefs or expectations of behavior), culture as *schemas* (which are perceptual and cognitive but not moral), and culture as *frames* (which are "abstract and general models of what is going on"). McLean applies these approaches to culture through the logic of two major cultural theorists. He turns first to the *generative dispositions* of Pierre Bourdieu, which emphasize the production of a cultural framework.[43] Then he reviews the theory of Harrison White, which seeks to expand the place culture in most elements of network theory.[44]

McLean's final five chapters portray five types of directional relationships between networks and culture, showing the insights that can come from each area of analysis.[45] He begins with the flow of "*cultural materials **through** networks*," via diffusion, contagion, virality, memes, and reinvention. He turns next to "*culture **from** networks*," in which links within networks generate identities and roles in the emergence of culture. "*Networks **from** culture*" addresses how participants' cultural preferences shape the links they form. "*Networks **of** culture*" treats culture as relational structures with meaning. Further, "*Networks **as** culture*" addresses the embedding and fusing of culture and networks in each other, as a particular culture may entail a kind of networking mentality.

Overlaps: networks and other structures

The discussion above has largely remained restricted to networks, defined narrowly as spatial relationships of edges and vertices. Network analysis may be simplified to groups consisting of numbers with little spatial detail; or it may be complexified to systems with dynamics and interrelations.[46] In addition, the logic of networks encounters and overlaps with several other logics, in which elements are grouped in various ways. This section provides compressed summaries of these other logics, indicating how they are related to networks and listing citations for further reading. Most of these terms mentioned here also appear in the concluding two sections of this essay, as factors interacting with networks.

Groups. Groups and networks are tied to each other at the base. **Graph theory** combines with **group theory** to form the framework of group analysis in the hands of mathematicians. It centers on unchanging elements organized as numbers, permutations, and matrices. The terms "graph theory" and "group theory" became nearly synonymous, and together they led to the field of abstract algebra.[47] In contrast with networks, groups focus on categories and numbers within categories; networks focus on relations among elements of groups, including spatial relations. In **social analysis**, groups are contrasted with individuals. In the hands of sociologists, micro-groups and groups have commonly been seen in dichotomous terms, distinguishing in and out groups, open and

[41] McLean, Culture in Networks, 30.
[42] McLean, Culture in Networks, 1.
[43] McLean, Culture in Networks, 42–47; Pierre Bourdieu, trans. Richard Nice, The Logic of Practice (Cambridge: Polity, 1990).
[44] McLean, Culture in Networks, 49–56; Harrison C. White, Identity and Control, 2nd ed. (Princeton: Princeton University Press, 2008).
[45] These are in chapters 4–8. McLean, Culture in Networks, 65–179.
[46] Influential extremes include artificial intelligence, beginning in the 1980s, had led to development of Artificial Neural Networks that can be trained to learn. At a more abstract level, Bruno Latour has proposed an Actor-Network Theory that includes everything within a system.
[47] For an excellent, concise summary of graph theory, see Versluis, "Network Concepts," 12–15.

closed groups, reference groups, or kin groups vs. voluntary associations. Grouping of people in this way tends to give little attention to variations within the group. Macro-classification of social groups is commonly done by religion, race, birthplace, ethnicity, and now by genetics. **Evolutionary classification** of groups is branched and hierarchical, including phyla, species, family trees, and sub-species—though these can also be phrased as networks.[48] A later section of this essay addresses the evolution of primates and humans, especially their social groups and networks.

Individual and group behavior. In an important study in intellectual history, Lars Udehn documented the rise and persistence of *methodological individualism* in the logic of social science.[49] The key narrative in his study is tracing how Max Weber, known as the sociologist of organizations, bureaucracy, and the rise of capitalism, focused his analysis on demonstrating that all these structures arose from individual behavior. Udehn did not seek to develop an alternative analysis at the level of social groups, but his work makes clear that, at the level of civic society, we still have little skill in thinking of group behavior and the nature of its balance with individual logic. Organizational theory, prominent in business schools, allows for group behavior, while social science disciplinary theory relies on reducing the group to individual behavior.

I-groups, we-groups, and intentionality. The study of scale, structure, and agency in human groups has been studied increasingly in recent times. George Rudé's 1964 study, *The Crowd in History*, explored the influence of unstructured, short-term groups in European history.[50] Subsequent work has clarified the issues of structure and scale in groups.

A turning point in the analysis of structure and agency in human groups came with the analysis of philosopher Raimo Tuomela in books published in 2007 and 2013.[51] Tuomela distinguished an *I-group*—in which individuals formed a group but continued to act in pursuit of their own individual objectives—from a *we-group*, in which individuals joined a group by agreeing to work toward the objectives of the group. He documented the logic and practice of this "collective intentionality"; he used game theory to propose proof that the logic of decisions and actions in a we-group were distinctive and irreducible to individual-level behavior. So far, the proof appears to stand. Therefore, the I-group/we-group framework identifies a key area of difference and overlap in human behavior. Personal networks are intimate but not contractual; institutions are contractual. Yet institutions include individuals thinking on their own behalf and through informal networks as well as in the logic of the institution. This complexity cannot effectively be reduced to individual behavior.[52]

Meanwhile, work progressed in both structure and scale within human and primate groups, though it alternated between approaches based on groups (emphasizing numbers within each group) and on networks (emphasizing spatial relationships among group members). The network approach led to studies of *connectivity* in groups, as in small-world networks. What holds the group together?

The continuing work on groups and networks showed that Tuomela's view of intentionality, formulated for *Homo sapiens* alone, required modification. Robin Dunbar and Michael Tomasello each, focusing on biological development of species, showed that there were additional levels of intentionality, which also appeared to suggest

[48] John Maynard Smith and Eörs Szathmáry, The Major Transitions in Evolution (Oxford: Oxford University Press, 1995).
[49] Lars Udehn, Methodological Individualism: Background, History, and Meaning (London: Routledge, 200).
[50] George Rudé, The Crowd in History: A Study of Popular Disturbances in France and England, 1730–1848 (New York:Wiley, 1964).
[51] Raimo Tuomela, Social Ontology: Collective Intentionality and Group Agents (Oxford: Oxford University Press, 2013). Tuomela, Philosophy of Social Practices: A Collective Acceptance View (Cambridge: Cambridge University Press, 2002).
[52] In a we-group, members gain entry through gaining expertise, agreeing to group objectives and to work for them.

that there were multiple levels of agency.[53] For humans and other primate species, the question remains, what holds groups together?

Institutions and organizations. Institutions are a distinct category of networks, especially because institutions are more formalized, contractual, and structured than other networks. Institutions focus completing specific tasks, and they require schooling and preparation of institutional members. In studies of the modern world, the terms *institution* and *organization* overlap greatly. For long-term world history, tracing institutions from their initial formulation to their current state is a topic of interest.[54]

Systems. The framework of *systems*, more elaborate in structure than networks or groups, emphasizes the interactions among elements and the overall function and dynamics of the system.[55] Systemic analysis allows for input to the system, transformation within the system, and output from the system. It allows for top-down or system-wide analysis, but also for bottom-up or local analysis. Network analysis, parallel to yet simpler than system analysis, includes distinctions between the overall properties of networks and properties of portions of a network.

Scales of analysis. Theory necessarily implies simplification of the topic under study. In studying complex systems with multiple scales of activity, one faces the choice of the level of complexity at which to set the analysis. The term *reductionism* refers to the use of a simplified model to explain a complex phenomenon.[56] In some cases, reductionism works well by highlighting a powerful underlying dynamic; in other cases, it obfuscates complications that would be influential. In the endless debates that result, one may distinguish reductionism as an analytical *strategy* from reductionism as a *tactic.* The social science strategy of explaining group behavior in terms of individual behavior, for example, is reductionist. Darwin's theory of natural selection was a successful example of reductionism. E. O. Wilson sought to extend that reductionism to human social affairs in *Sociobiology*, but practical studies of human society biology have relied on specific sub-theories of genetics, development, and social sciences.[57] The result is overlaps in topics, labeling, modes of study, and terms. Thus, the term World Wide Web was coined in 1989, giving a specific meaning to the term "web," but it was really an update of the network known as ARPANET, created in the 1970s. This and other examples may remind researchers and readers of network analysis to be attentive to the specific definitions of terms and their relationships in each publication.

Overlaps. To restate, the spatial logic of *networks* connects closely to the logic of *groups* (consisting most basically of quantities of elements will little spatial detail), and to *webs* (which characterize aggregations of spatial connection with little attention to detail). The words and concepts for networks, groups, and systems go back millennia in time, and those meanings and usages will surely persist. In addition, mathematical statements of network relations, formulated especially from the seventeenth to nineteenth centuries, have been reworked in many ways with the technology and insights of more recent times.

In the era since 1950, exploration of the full array of networks and other groupings has expanded and diversified greatly. In philosophical terms, this corresponds to a gradual change in thinking from philosophical positivism (the strategy of isolating problems and studying them with small numbers of variables) to interactive

[53] On intentionality and its levels, see Daniel C. Dennett, The Intentional Stance (Cambridge, MA: MIT Press, 1989); John R. Searle, The Construction of Social Reality (New York: The Free Press, 1995); Michael Tomasello, Alicia P. Melis, Claudio Tennie, Emily Wyman, and Esther Herrmann. "Two Key Steps in the Evolution of Human Cooperation: The Interdependence Hypothesis," Current Anthropology 53 (2012):673–686; Tuomela, Social Ontology; Manning, History of Humanity.
[54] On institutions, see Johathan H. Turner, Human Institutions: A Theory of Societal Evolution (Lanham, MD: Rowman & Littlefield, 2003); Tuomela, Social Ontology; and Manning, History of Humanity.
[55] Ludwig von Betalanffy, General Systems Theory (Braziller, 2015)
[56] Michel Morange, trans. Matthew Cobb, A History of Molecular Biology. Cambridge, MA: Harvard University Press, 1998).
[57] E. O. Wilson, Sociobiology: The New Synthesis (Cambridge, MA: Harvard University Press, 1975)

and multivariate thinking.[58] To my knowledge, no general strategy has been proposed for working with such multidisciplinary overlaps, but researchers should be on the lookout for rules of thumb that facilitate the location and acquaintance with relevant adjoining fields of study.

Dunbar's analysis of primate networks and groups

Robin I. M. Dunbar, a biologist, evolutionary psychologist, and anthropologist now at Oxford University, has devoted a long career to primate studies, with implications in numerous directions. In his 1988 overview of *Primate Social Systems*, he gave substantial attention to the close-knit and long-term social groups of primate species, and to the relatively large brains that appeared to result from all the energy that was put into sustaining numerous close relationships.[59] From 1990, he emphasized that primates from lemurs to apes had characteristic intimate groups and community groups, the former for reproduction and foraging, the latter for defending the population. He also emphasized the "fission/fusion" character of primate social organization, including seasonal and other shifts in gathering by smaller or larger groups. In articles that expanded quantitative study of primate evolution, he argued for a clear relationship of the size of the neocortex and the size of the community for apes and hominids, using regression analysis and fossil skulls to estimate the brain size and community size of extinct species, and estimating 150 as the characteristic size of the *Homo sapiens* community.[60] This figure, known as "Dunbar's Number," has been widely applied.

Figure 5 shows a summary of these estimates published in 2012, ordered by species but not by time frame. Of the species shown in Figure 5, all were bipedal except genus Pan (chimpanzees) at left. *Homo habilis* created the earliest stone tools; for *H. ergaster* and after, the larger Acheulean hand-axes were standard tools. *H. Heidelberg,* with still larger brains, relied on fire and cooking; the characteristic average group size of each is shown at left.[61]

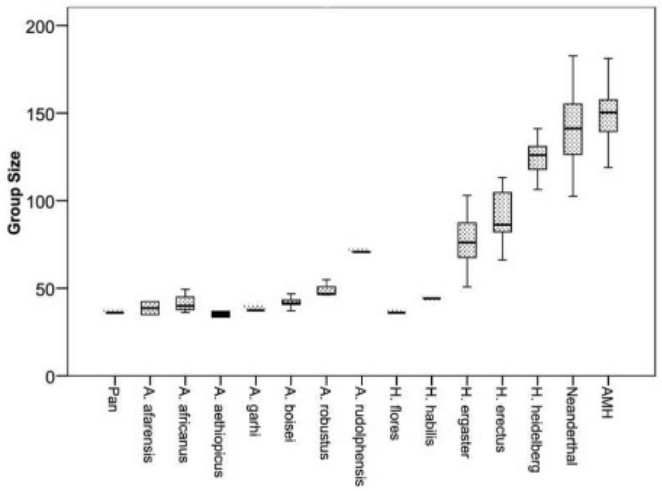

Figure 5. Primate species by community group size, as determined by brain capacity.
(From Gowlett, Gamble and Dunbar, 2012, 696.)

[58] Patrick Manning, *Methods for Human History* (New York: Palgrave Macmillan, 2020).
[59] Dunbar, *Primate Social Systems* (London: Croom Helm, 1988).
[60] R.I.M. Dunbar, "Neocortex size as a constraint on group size in primates," *Journal of Human Evolution* 22 (1992): 469–493; Leslie Aiello and Robin Dunbar, "Neocortex size, group size and the evolution of language," *Current Anthropology* 34 (1993): 184–193.
[61] The precise figures for these relationships have been revised after continuing research. For critique of Dunbar's Number, see the Wikipedia article on "Dunbar's number."

Beyond this basic relationship, Dunbar went on to articulate a broader "Social Brain hypothesis," showing the complex changes that arose from the basic motivation of building social networks for individual self-reliance and social advances. The time spent grooming individual family members and friends to sustain groups meant that time for foraging was always under pressure. Brains grew but required extra nutrition. A revised pelvis because of bipedalism combined with brain growth and the larger heads of newborns, making childbirth painful and dangerous. As Dunbar and colleagues explained, births then came at a less-mature stage and the infants required a longer period of nurture. Social devices such as laughter and chanting strengthened social groups; eventually fire and cooking made digestion more efficient, and meat from hunting enabled more brain growth and larger groups.

In research on modern-day human groups, Dunbar showed that groups of roughly 150 people could be found in many social circumstances. As shown in Figure 6, Dunbar argued that village societies, tribal groups, religious communities, and even Twitter networks could be seen to maintain the predicted size of a human community. Of course, these modern groups were parts of much larger societies, but Dunbar was able to argue that the inherited ability to sustain groups of 150 was still in place.

grouping	sample	size	source
community size			
Domesday Book (1087 AD) (mean village size)		150	[26]
C18th English villages (mean size)		160	[27]
Italian alpine communities (1250–1800 AD)		176	[28]
tribal societies (community size)	9	148	[29]
hunter–gatherer societies (clan size)	339	165	[30]
E. Tennessee rural community	1	197	[31]
Hutterite farming communities	51	107	[32]
'Nebraska' Amish parishes	8	113	[33]
Church congregations (ideal size)		200	[34]
company (mean, WW2 armies)	10	180	[35]
academic research specialities	13	100–200	[36]
Twitter networks	60 790	100–200	[37]
average		158.0 ± 28.7 s.d.	

Figure 6. Human community sizes today. (From Dunbar 2020, 3)

In a 2012 article in *Current Anthropology*, Dunbar and colleagues reaffirmed the primate pattern of stable groups at the intimate level and community level, summarized these elements and other elements of the social brain hypothesis, and added a fuller analysis of levels of *intentionality* that they had been developing during the previous decade.[62] Dunbar drew the term *intentionality* from the work of philosophers Daniel Dennett and John Searle, as well as from the early studies of Michael Tomasello, a developmental psychologist who developed a slightly different set of levels of intentionality.[63]

Dunbar characterized intentionality as levels of "mind reading" skills by succeeding primate species. He proposed the first level of intentionality, existing in most mammals, as the belief that something is so. At the

[62] John Gowlett, Clive Gamble, and Robin Dunbar, "Human Evolution and the Archaeology of the Social Brain," *Current Anthropology* 53: 6 (2012): 693–710. Dunbar began writing of intentionality as early as 2003.
[63] Dennett, *Intentional Stance*; Searle, *Construction of Social Reality*; Tomasello et al., "Evolution of Human Cooperation." Tomasello had three levels of intent; Dunbar had five.

second level, he argued that individuals were able to attribute states of mind to another and that this was arguably sufficient for making tools. A third level of intentionality was sufficient to support the interactions of laughing and crying, which arguably built ties among individuals. The fourth level of intentionality could support emotions such as guilt and shame, activities such as dance and material culture, and ultimately syntactic language. A fifth level remained advanced for modern humans, but Dunbar argues that Shakespeare relied on it in his construction of *Othello.*

In one further expansion of implications of the social brain hypothesis, the 2012 article advanced a rephrasing of the intimate and community groups, as they were initially described, portraying them as *networks*. Dunbar distinguished "natural human groupings" from "personal social networks," but argued that both types of grouping shared the same range of scales.[64] As shown in Figure 8, and in an analysis limited to the relatively large groups of *Homo sapiens*, the initial notion of two principal levels of groups (5 and 150) had expanded to a much larger number of groups. The intimate and community groups remained the most important, but it now appeared that there was a sequence of groups of 5, 15, 50, 150, 500, 1,500, and beyond. In a "fractal" relationship, it is seen that each level of group is quite close to 3 times that of the preceding group. Figure 7 labels the groups (or network size) from the perspective of Ego, the individual at the heart of personal networks. The strongest relationships, clearly, are in the smallest and closest portions of the network.

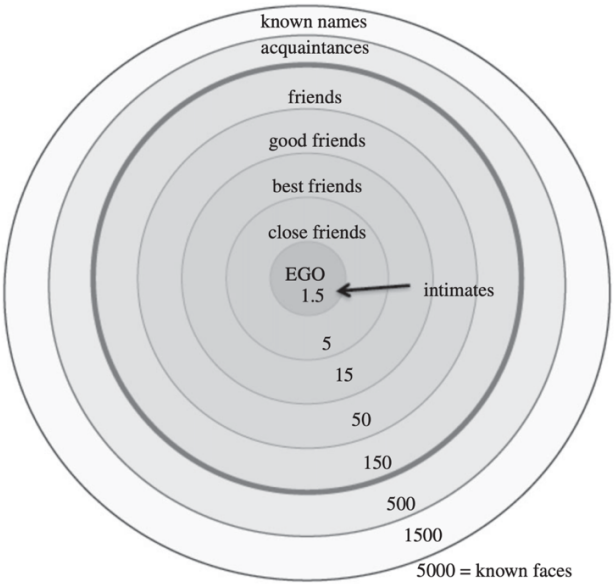

Figure 7. Ego networks, showing fractal organization of group scales. (Dunbar 2020, 8)

[64] R.I.M. Dunbar, "Constraints on the evolution of social institutions and their implications for information flow," *Journal of Institutional Economics* 7 (2011): 345–371.

In Figure 8, groups of the same range of scales are presented as community groups or small-world networks. The Ego-based network is listed at the left of Figure 8, while the community equivalent is listed on the right (though note that the groups of 50 and 150 are listed together as "extended" from the perspective of Ego).

Ego-based network	Principal resource	Size	Sample descriptors of modal size
Intimate	Emotional affect	3–7	Support clique, significant others, nuclear family
Effective	Material exchange	10–23	Sympathy group, friends, minimum band, local group
	Ecological unit	35–70	Band, overnight camp
Extended	Symbolic "positive style"	100–200	Friends of friends, connubium, clan, community, active network
	Unknown	~500	Megaband
Global	Symbolic "negative style"	1500–2000	Nonsignificant "others," tribe, linguistic family

Note. Sample descriptors for small-world societies are taken from primate, anthropological (hunter-gatherers), and sociological literature. Following Zhou et al. (2005) and Hamilton et al. (2007), two additional layers of grouping (at ~50 and ~500 individuals) are recognized.

Figure 8. Networks and resources. (Gowlett, Camble and Dunbar, 2012, 697; after Gamble 2007)

Up to about 2000, Dunbar's publications emphasized the basic message of the social brain hypothesis for primate evolution, with Dunbar's number of 150 community members as the statement of that thesis for *Homo sapiens*. After 2000, however, his research diversified to include three additional dimensions. For one, his attention to fission/fusion patterns in primate social structure—the seasonal and regional shifts among groups of varying size—led to a more comprehensive approach to groups within the community. Dunbar identified multiple levels of groups, useful for various purposes as shown in Figures 7 and 8 above. In a second initiative, he identified levels of "intentionality" that indicated the effectiveness of primate organisms in reading the thoughts of others, as described above. In his fourth initiative, Dunbar began to restate primate groups as networks. This timing fit with the advances in analysis and simulation of networks seen in the late 1990s (described clearly by Versluis). Dunbar began and continued simulation of network behavior. Further, the restatement in terms of networks highlighted the specifics of interrelations, showing the limits on the size and extent of networks.

The progress in all four areas, but especially in networks, led Dunbar to offer critique of other interpretations of group behavior. The work of Stanley Milgram in the 1960s on the "small world" circulation of letters had raised optimism that communication within huge communities might be feasible. Granovetter's 1973 thesis of the benefits of "weak ties" in communication reinforced such thinking, so the public was ready for Guare's "six degrees of separation" in the 1990s. Milgram's small-world experiment had indeed confirmed the potential of rapid connections among some people who had little knowledge of the overall system, but Dunbar emphasized that not everyone in the system was connected in that way. Similarly, Dunbar expressed doubt about Granovetter's well-known 1973 claim that weak ties were especially important in acquiring information by diffusion. As Dunbar saw it, the inner layers (stronger ties) of networks have most impact on the likelihood of acquiring information by diffusion, not the outermost layer (weak ties). In his one paper on institutions, Dunbar emphasized that institutions can be managed informally if they have less than 150 members. But when they grow beyond 150 members, they require formal management structures to address two information bottlenecks: "casual bottlenecks," in which information does not flow where it should, and "deliberate bottlenecks," in which rivalries arise in because subgroups do not know each other well enough.[65] In a further critique, Dunbar asserted an error in the analysis of cultural evolution. From the 1980s, Robert Boyd and Peter J. Richerson led in developing "cultural evolution," an approach relying on the biological mechanism of kin selection or "dual inheritance" to build cooperation among humans.[66] On this basis, they sought to explain the rise of ethnic groups among humans

[65] Dunbar 2011, 363. Institutions, not defined, are treated as organizations with members and norms.
[66] Robert Boyd and Peter J. Richerson, *Culture and the Evolutionary Process*, (Chicago: University of Chicago Press, 1985).

without reference to language, by modeling the interactions of social learning and calculating expanding levels of cooperation. As Dunbar noted, however, they relied on a "mean field model" of community—effectively a lattice network with maximal connection among nodes—thus greatly exaggerating the degree of cooperation among nodes. Dunbar reproduced their results but also revised them by limiting network connections only to nearby nodes, getting results that fit his vision of small and local human networks.[67]

For an audience of epidemiologists seeking advice on policies, Dunbar published a response to the COVID-19 pandemic, based on his network analysis and current simulations. In addition to reaffirming his arguments on the concentration of human networks (60 percent of social effort devoted to the closest 15 people), Dunbar emphasized that the networks include both family and friends, but that ties to kin are closer and more lasting than ties to close friends. Since birth rates and family sizes have declined worldwide within the past century, the proportion of kin the total number of personal network links has declined, and networks have become less tightly knit.[68]

Dunbar argued that epidemiologists had exaggerated the connectivity among people, as they were using algorithms that were easier to calculate and neglecting the small size and more limited connections of human networks. With such highly infective disease agents, infection would spread rapidly in any case. But if most people agreed to restrict their contacts to their personal networks, the transmission of disease ought to be greatly reduced. Nevertheless, fear of
infection could reduce trust among network members—moreso among friends than kin. As a result, COVID-19 was predicted to reduce ties among friends, which could only slowly be re-established. In other theses on group behavior expressed in this article, Dunbar spoke of "management cliques," which could arise when some groups of friends set additional requirements for membership, creating groups that could make decisions more rapidly. He also described the hierarchy of human groups as a fractal structure.

Dunbar and his associates, while carrying on this quantitative network analysis, continued to study primate and human evolution more broadly. They published an updated version of *Lucy to Language*, a 2014 volume in which Dunbar was joined by co-editors Gamble and Gowlett, with 21 chapters of detailed analysis by numerous co-authors.[69] The balance of field study, laboratory analysis, and quantitative modeling—carried out by a large and growing team—seems to have facilitated advances in analysis and interpretation in each research area.

Dunbar's research, for all its breadth and depth, is not a comprehensive analysis of primate evolution or the Human System. It has effectively pursued multidisciplinary approaches to primate behavior and networks from a bottom-up perspective; through the issue of COVID-19, the approach is now being brought to bear on connections between local networks and global patterns. There are other major issues that need to be explored from a parallel, bottom-up perspective: the emergence of syntactic language, the emergence and evolution of social institutions, the changing patterns of migration, and more.[70] In addition, however, a comprehensive analysis of the Human System requires articulating top-down approaches to early human history, although such top-down analysis can only be effective if it is closely attentive to the evidence from bottom-up approaches.

The work of Dunbar and colleagues is showing how much bottom-up work remains to be done in understanding human society, by showing the intricacy of the lower levels of human society and by showing the

[67] R. I. M. Dunbar, "Structure and function in human and primate social networks: implications for diffusion, network stability, and health," *Proceedings of the Royal Society A* 476 (2020): 20200446.
[68] Dunbar, "Structure and function," 9, 14, 17–19.
[69] R. I. M. Dunbar, Clive Gamble, and J. A. J. Gowlett, *Lucy to Language: The Benchmark Papers* (Oxford: Oxford University Press, 2014). The initial version was Donald C. Johanson and Edgar Blake, *From Lucy to Language* (New York: Simon & Schuster, 1990); revised edition 2006.
[70] Robin Dunbar, *How Religion Evolved* (Penguin, 2022).

continuing close social parallels of humans and other primate orders. Network studies have recently become more important in the overall analysis of the project that began with the Social Brain hypothesis. I think that the research results summarized in this section show that network analysis—applied both as basic principles and as elaborate simulations—can be highly valuable in analyzing human social structure and its changes.

Networks in world history

While previous sections of this study have focused on logical and analytical elements of networks, this section turns to some of the historical problems associated with networks. In this section, Figure 9 displays 12 questions of long-term human history, suggesting that the responses may take the form of dynamics in which networks were central. For most of the questions, the reader is left to consider the possibilities; for the four that are in boldface, a discussion follows, adding some detail. In each case, I ask the reader to consider both networks and institutions, and to consider what role each played in world-historical change.

I will first define the key terms: social networks, as we have seen, are collections of actors, linked in certain configurations. Formal institutions, such as states and organized religion, differ from networks in that they have a defined membership, they are oriented toward completion of a specific task, and the members agree to work toward completion of that task. We could argue that all institutions are networks at base, with linked actors in certain configurations, and with the additional criteria of formal membership and agreed-upon common tasks. In most histories, individuals (often portrayed heroically) and institutions (states and armies) get most of the attention. But as we have been reminded by this review of networks, networks of personal relations probably occupy more human energy than do institutions. Households—which can be seen as small biological networks—produce and nurture the offspring for the next generation. Families, friends, and communities comprise the other basic networks. Networks may also cross boundaries and exchange information, along with cross-boundary institutions.

Networks both small and large function through individual needs for personal alliances. Institutions, in contrast, function through assembling members to share in focusing on set tasks. One key historical question: How have networks and institutions each stretched to reach larger scales, given the inherent constraints that each faces? The analysis in earlier sections, while it does not yet show specifics on how networks and institutions comprise basic elements of world history, does reveal some dynamics and linkages that seem relevant for further study. Of the 12 world-historical dynamics noted in Figure 9, four have been provided with additional discussion.

Years ago	Networks and institutions in world-historical dynamics
400,000	Intimate and community networks—how did human households arise?
400,000	How did early *Homo sapiens* spread to occupy the full African continent?[71]
200,000	How much did genetic vs. conscious change contribute to human cooperativeness?
70,000	How did syntactic language turn the human community network into an institution?
70–20,000	**How were 150-member communities sufficient to achieve global migration?**
20,000–5000	What was the role of networks and institutions in expanding the scale of human society?
10,000–4,000	**What were the roles of households, networks, and institutions in agriculture?**
7,000–2,000	What explains the proliferation of technical and social institutions in this era?
1,200–400	**What explains the world-wide network of commerce and knowledge, 800–600 CE?**

[71] Among other things, genetic research shows that varying populations of *Homo sapiens* had migrated and become widespread in Africa before the expansion of speaking humans from East Africa. Lipson et al., "Ancient DNA and deep population structure in sub-Saharan African foragers," *Nature* online, 23 Feb. 2022).

300–100	**What were the networks and institutions of capitalist economy and global conquest?**
200	What was the role of institutions and networks in generating the Anthropocene?
at present	Is the Human System verging on collapse?

Figure 9. Hypothetical networks in world-historical dynamics

Migration. From 70,000 to 20,000 years ago, communities of *Homo sapiens* expanded from East Africa to the whole of Africa, to most of Eurasia, to island Southeast Asia and Australia, and into the Americas. The migrants were presumably organized into communities of roughly 150, each with its own language, that settled and learned to live in sharply varying ecological niches. Each language community, sustained by the years of language-learning by each of its members, was the main institution of each group. What other networks existed, either within the language community or reaching beyond it, and what roles did they play in social change. Was the language community also a network? How much communication was required among communities?

Agriculture. Agriculture arose independently in many tropical and subtropical regions. Its earliest stages, perhaps 15,000 years ago, were intensive gathering of grains and roots; the process of planting and nurturing successive crops continued from roughly 10,000 to 4,000 years ago. What types work were carried out by households, lineages, villages, communities, and larger groups? Household gardens could be tended by women, their children and the old. Clearing might require communal work. Was storage done by households or by larger units? These distinctions show that agriculture was not a single occupation but required several levels of social organization.

Global network of commerce and knowledge, 800–1,600 CE. While this era is noted for its rise and fall of empires and expansion of religious institutions, there remained places and times in between the empires and between the religious communities. Mariners of Arab, Malay, Chinese, Mediterranean, and Norse ancestry carried commerce, along with African and Eurasian caravans. If the vessels and caravans were structured institutions, the marketplaces and fairs were networks open to all. As literacy expanded, letters and documents moved in all directions across the Old World. While the Mongols controlled as much as half of Eurasia for a century, this long era arguably centered more on expanding networks than on imperial institutions. What specific types of network activity might have characterized this era?

Capitalist institutions and global conquest. Capitalism arose especially in the eighteenth century as a mix of networks in markets for labor and commodities at both local and global levels, along with the rise of certain new institutions that influenced global power relations. Jonathan Scott has recently portrayed the succeeding revolutions and close but tense commercial alliances described in national terms as linking the Dutch, the English, and the Americans. In terms of specific interest groups, the key figures were merchants in each region who gained substantial interest over the state. Their political influence enabled them to raise tax revenue and manage warfare far more effectively than absolutist monarchies. Starting in 1688, the joint rulership of England and Netherlands launched the idea of shared rules for pro-merchant states. The same merchants created new financial institutions enabling more rapid flow of capital to productive investments, especially from 1760. Further steps in this evolution continued through the nineteenth century, as more European nations and even Japan joined this alliance of pro-capitalist and pro-imperial states. So far, this version of the story centers on institutions rather than networks, leaving open the question of the role of networks in this era of great economic and political change.

Conclusion

The metaphoric use of the term “network” will surely continue, particularly as individuals speak of their personal and professional networks. In addition, academics will benefit from building applications of formal network theory and terminology for studies of the past. The summaries of network tools and insights presented

above—from the works of Versluis, McLean, and Dunbar—provide a start, and each of those works goes far beyond the points presented here.

Yet there seems to be no shortcut to a network-based approach to history. The section just above suggests that the previously displayed network tools are valuable in analyzing human history, but that it will take time and original thinking to fit network analysis to the conditions and logic of historical analysis. The approach here has been conceptual rather than empirical, exploring basic models that can gradually be implemented in a bottom-up approach to historical situations. At the same time, the understanding of long-term human experience also requires keeping an eye on the big picture. I have proposed the notion of the Human System—an evolving, expanding, and transforming system of interactions, inhaling global resources, and expelling waste of various types. That system must rely on many sorts of networks, but so far we can scarcely label them or show how they have been connected.

The strategic task for studying networks in history, in my view, begins with bottom-up analysis to seek hypotheses on the functioning of networks at each scale, with attention to persistent links from intimate scales to maximal scales. The clearest objective is to gain information on how to trace and explain the expanding scales of human society. Nevertheless, the side effects of this work might include the discovery of some emergent system properties, arising from network interrelations, that lead in directions different from expansion—one example is the argument for the dynamics of households in human history.[72]

One may begin these tasks with the elements of network analysis. How do we identify the nodes and the links in social network approaches that are focused on interactions among nodes? How do we identify the edges and vertices of network approaches that are focused on flows of materials and information? Beyond these elements, we can give attention to the various types of networks—lattices, random, and small-world networks—and to the many topics to which networks apply. Questions will arise on the degree of nodes, on branching or nested networks, and on the balance of network diameter and connectivity of network regions. At a larger scale, one may seek hypotheses that distinguish evolving *vertical hierarchies* from evolving *horizontal networks* in aspects of social change. Take the development of capitalism, for example: I have tended to believe that capitalist organization, in addition to its obvious expansion of hierarchical order, has also entailed innovative expansion of horizontal networks.[73] But am I wrong? My searches for literature on horizontal networks have led to very meager results.

The studies of networks and social relationships, exemplified here by Dunbar's work, show how deep and persistent is human devotion to building and maintaining close personal relations, especially for intimates but also at a distance. Recognizing the value of human effort in maintaining networks may reshape the calculations of economics. In any case this insight gives attention to the importance of friendship in social life, shows possibilities for sharing information at a distance, suggests how management cliques may form and operate, and points toward the importance of individual investment in learning for functioning within institutions.

This introductory survey has not resolved the historical problem of how local networks link to each other and generate or link to global networks. But the overview has indicated the density and the significance of small networks in human affairs, especially from the intimate groups of households up to communities of 150. We have also seen some mechanisms by which these networks may link more broadly.

[72] Manning, "Households."
[73] Manning, *History of Humanity*, 235, 244–255.