Glossary:
Networks and Ethnography

http://eclectic.ss.uci.edu/~drwhite/turks/Networks_and_Ethnography.htm [1]

Subconcepts or distinctions under a listed entry are marked in bold type while those that are italicized also have separate entries. The vocabularies we use derive from anthropology (kinship, social roles), sociology (social networks, norms), graph theory (graphs, networks), complexity theory (fractals, power laws) and hybrids (network concepts for kinship). Other terms that require illustration and conceptual understanding are given where needed in the text.

The endnotes to the glossary give commands for Pajek software (Batagelj and Mrvar 1998) used to implement operations defined by analytical terms: These provide an inventory of software operations used in this book, including occasional use of UCINET (Borgatti, Everett, and Freeman 1992). Comparable operations exist in most of the software packages for network analysis, which now include NetMiner and JUNG, both downloadable from the web. Pajek and JUNG are freeware; UCINET and NetMiner are available at academic prices. See:

Pajek http://vlado.fmf.uni-lj.si/pub/networks/pajek/
JUNG http://jung.sourceforge.net/
UCINET http://www.analytictech.com/ucinet_5_description.htm
NetMiner http://www.netminer.com/NetMiner

All these links are clickable in the online glossary at
http://eclectic.ss.uci.edu/~drwhite/turks/Networks_and_Ethnography.pdf

Useful kinship glossaries and software sites are these (by author):
Schwimmer: http://www.umanitoba.ca/anthropology/tutor/glossary.html
Murphy: http://www.as.ua.edu/ant/Faculty/murphy/436/kinship.htm
White: http://eclectic.ss.uci.edu/~drwhite/pgraph/pgraph.html

General anthropological terminology, including social organization are covered in sites by Kottak and a compiler of anthropological sources:
Kottak:
http://highered.mcgraw-hill.com/sites/0072426527/student_view0/chapter15/key_terms.html
a compiler: http://www.webref.org/anthropology/anthropology.htm

Affinal. Two persons are affinals if a relation between them can be traced that includes marriage. **In-laws** are the consanguines of a spouse or the spouses of consanguines, but longer chains of relationship such as the spouse of a consanguineal of a spouse of a consanguineal (e.g., HZHZ) or a consanguineal of a spouse of a consanguineal (e.g., BWB) are affinals in the more extended sense of the term. See: Consanguineal.

Affinal relinking refers to the case, common in European villages and many other parts of the world, where the bride and groom are not blood relatives, but are linked by prior marriage between their families. See: Marital relinking.

Agnatic tie. A relation between two descendants of the same ancestor traced only through males. Synonym: **Patrilineal.** A **patrilineage** is a corporate group whose members share agnatic descent. See: Descent, Descent group, Clan, Uterine tie, Cognatic tie, Unilineal, Modes of reckoning descent.

Automatic drawing, spring embedding.[2] Optimal layouts of graphs that minimize line length, in which more cohesive nodes tend to be more clustered, and hierarchical clustering of cohesive sets can be easily superimposed. **Energized graphs** drawn in the Pajek program implement these automated procedures. **Energy commands** move nodes to locations that minimize variation in line length. Lines act as springs that pull vertices together to better positions until they are in a state of equilibrium with the pushing apart of disconnected nodes. These procedures are known as **spring embedders (**de Nooy, Mrvar and Batagelj 2003). See: Methods of graph and network analysis.

Balance.[3] A signed graph is **balanced** if it has no cycles with an odd number of negative edges and by an **equivalence theorem** has a bipartition of nodes into two sets such that all positive edges are among nodes within the same partition while all negative edges are between nodes belonging to the other partition. See: Triad census (for computation), Graph theory, Signed graphs, Micro-macro linkages, Structural properties of graphs and networks.

Bicomponent: see k-component.

Bridewealth. A transfer of ***wealth assets*** from a husband's wealth-holding group to the wife's contingent on marriage, in exchange for reproductive rights transferred from the wife's group (e.g., over their daughter's offspring) to the husband's (e.g., children are retained by the man's lineage). Bridewealth is typically paid in animals such as cattle that qualify as a wealth-asset. **Bride price** is a term that can be used when only consumables are transferred at marriage in contrast to bridewealth, but the term is out-of-date because of the inappropriate association with purchase. **Bride payment** is roughly synonymous with bridewealth except that either ***wealth assets*** or consumables may be transferred. See: Marriage transfers of assets, Wealth assets, Dowry.

Centrality.[4] A property of a node that depends on its relation to other nodes in a graph: **degree** centrality is the number of lines incident to a node; **closeness** centrality is a function of the number of lines in all the shortest paths needed to reach all the other nodes in a graph; and **betweenness** centrality (Freeman 1977, 1980) is a function of the number of pairs of other nodes in a graph weighted by the proportion of the shortest paths between each pair that pass through a given node. These are useful to measure the **activity** of a node in a network, the potential **influence** of a node over others, or the **control** a node has in mediating connections between others, respectively. **Recursive centrality**[5] is the extent to which a node is connected to others that are central and is measured by the first eigenvector in a principal components analysis of a network matrix. Is also known as **eigen** centrality (*eigen*=own, in German, connotes that every matrix has unique principal component vectors whose vector product sums reproduce the matrix; see ***Eigenvalue/eigenvector analysis***). See: Centralization, Graph, Structural properties of graphs and networks.

Centralization.[6] A measure of the extent to which a graph has the greatest possible difference of centrality between the most central node and each the other nodes. For each measure of the centralities of individual nodes, the centralization measure of the graph varies between 0 and 1, with 1 for most centralized possible graph, which is a star (Freeman 1977, 1980). Centralization can be compared across different networks. See: Centrality, Graph, Structural properties of graphs and networks.

Clan. A descent group or category whose members trace descent from a common putative ancestry, where genealogical links back to a single apical ancestor are not known. See: Descent, Descent group, Agnatic tie. Uterine tie, Cognatic tie, Unilineal, Modes of reckoning descent.

Clustering, clustered graph.[7] A signed graph is **clustered** if it has no cycles with a single negative edge and by an **equivalence theorem** has a partition of nodes such that all positive edges are among nodes within the same partition while all negative edges are between nodes belonging to different partitions. See: Graph theory, Signed graphs, Micro-macro linkages, Structural properties of graphs and networks.

Clustering coefficient. The local clustering of each node u in a graph is the ratio of complete triples u, v, w to triples where pairs u-v and u-w have ties. See: Triad census (for computation), Curvature coefficient, Graph, Structural properties of graphs and networks.

Cognatic or **Bilateral tie.** A relation between two descendants of the same ancestor. A **kindred** is an ego-centered group of bilateral kin who often assemble for celebrations or life events. See: Descent, Descent group, Clan, Agnatic tie, Uterine tie, Unilineal, Modes of reckoning descent.

Cohesion and structural cohesion.[8] The cohesion of a network or subnetwork is measured by tie **k-connectivity** (White and Harary 2002): the minimum number k of nodes that must be removed to disconnect it. To say that a graph has connectivity k is to say, by an **equivalence theorem**, that every pair of nodes is connected by k or more completely distinct paths (Harary 1969). We refer to k-connectivity as **multiconnectivity** or node-connectivity and refer to levels of multiconnectivity as implying different numbers of node-independent paths. Pairwise connectivity is the number of node-independent paths between a given pair of endnodes, where two paths are node-independent if they have no nodes in common except for their endnodes. This is a classical conception of cohesion in graph theory, but so relatively complicated to compute that network analysts only began using this concept following Moody and White (2003); compare with Friedkin (1998). ***Exocohesion*** is a weak form of cohesion based on multiconnectivity among a set of nodes but where connecting paths may include nodes outside the focal set. In contrast to cohesion, the **adhesion** of a network or subnetwork is measured by k-edge-connectivity (White and Harary 2002): the minimum number k of edges that must be removed to disconnect it. See: Graph, k-components, Exocohesion. Structural properties of graphs and networks, Automatic drawing.

Complexity. Interaction between a system and its changing environment is **complex** when some of the system responses to changes are on longer time scales than the tempos of environmental change. This implies that complex systems enfold **memory** into their internal states. Interactive processes with different time-lags typically lead to non-linear dynamics.

The Arthur Iberall measure of complexity based on dynamics involves the spectrum of ratios of response times that exceed external interaction times. See: Complexity theory, Micro-macro linkages, Emergence and emergents, Tipping point, Power-law or scale-free distributions.

Complexity Theory. Complex systems have embedded interiors with many interacting parts, networks, and fields. From the viewpoint of mechanics, emergent field processes often lead to 'surprising' results that are not reducible to a mechanical or deterministic account. Emergent behaviors at one level are not determined by the embedded levels that produce them but are the result of complex interactions. See: Complexity, Micro-macro linkages, Emergence and emergents, Tipping point, Power-law or scale-free distributions.

Consanguineal. Two persons are **consanguines** if they have one or more common ancestors, e.g., the reciprocal pair MBD/FZS is a consanguineal relationship. See: Affinal.

Consanguineal relinking. Marriage between consanguineal relatives. See: Marital relinking.

Constraint (on behavior). One or more external circumstances that together limit the scope of an action or behavior.

Curvature coefficient. For ties that are reciprocal between social units in a network, the local curvature of each node u in a graph is the ratio of **complete triples** u, v, w to triples where u-v and v-w have ***reciprocal*** ties. Clusters of adjacent nodes with high curvature constitute a **topology** of a network (Eckmann and Moses 2002). This measure may be used with a multilevel graph that superimposes on the raw network a graph of induced relations among subsets of nodes that belong to social, possibly overlapping, units. See: Triad census (for computation), Clustering coefficient, Graph, Structural properties of graphs and networks.

Descent, Descent Group: The tracing of **descent**, whether real, putative, or fictive, is through parent-child links in successive generations. A **descent group** is a socially recognized multi-generation group of persons linked by inheritance rules with membership based on tracing common descent. See: Clan, Lineage, Agnatic tie, Uterine tie, Cognatic tie, Unilineal, Modes of reckoning descent.

Dowry. A transfer of consumables or ***wealth assets*** from the wife's group to the wife contingent on her marriage. Note the asymmetry with bridewealth: dowry transfers are usually not to the husband or husband's group but to the wife (Bell 1998). See: Marriage transfers of assets, Bridewealth.

Edge Betweenness and Cohesion.[9] Edge betweenness is a centrality measure of the number of pairs of nodes in a graph weighted by the fraction of shortest paths between each pair that pass through a given edge. Girvan and Newman (2002) use ***hierarchical clustering*** of edges with low betweenness to identify **embedded cohesive hierarchies**. See: Cohesion, Centrality, Graph, Structural properties of graphs and networks. Hierarchical clustering.

Eigenvalue/eigenvector analysis.[10] Because a network can be represented by a matrix, matrix mathematics can be used to decompose a matrix by a series of paired eigenvalues and eigenvectors that reconstitute the cells in the original matrix as sums of eigenvalue-weighted eigenvector products. If the first few eigenvalues are highly weighted, the original matrix or network can be reduced by close approximation to a linear combination of correspondingly few vectors. See: Methods of graph and network analysis.

Emergence and emergents. Emergence derived from an **emergent property** is in the simplest sense a structural property that is a product of interaction and has **configurational effects**, also a product of interaction, on nodes or relations elsewhere in the network (Chapter 1). That is, it has measurable predictive consequences and empirical tests of such hypotheses support such effects. Emergents may be classified as **non-local** when they have no known *micro-macro linkages* and as **local emergents** when the micro-macro linkages that produce them are known. Unlike emic concepts that field researchers derive from the concepts and linguistic usage of community members, emergent patterns in social networks are etic, and stated by the researcher, usually in the form of descriptive patterns or hypotheses. One of the accomplishments of **simulation** research in complex interactive or **complex adaptive systems** (CAS) is to discover new non-local emergents, i.e., ones that were not obvious from micro-macro linkages. **Emergence** is a term used in CAS and simulation studies for complex and unexpected outcomes from simple rules of interaction. A scientific definition that includes the surprise as an element in insufficient, however, because that surprise may pass if micro-macro linkages are discovered that explain it. See: Complexity, Complexity theory, Network-defined concepts in social behavior.

Emergent group. A group that can be identified through network analysis of structural cohesion but may lack well-known elements of self-definition, such as a name and socially recognized membership. In network analysis, a cohesive component (see ***k-component***) is an emergent group with clear-cut boundaries. See: Network-defined concepts in social behavior. See: Structural endogamy, Cohesion and structural cohesion.

Emergent role. A social role that is not explicitly named or expressed but that can be identified by network analysis. In network analysis, **blockmodeling** social positions on the basis of **structural** or **regular *equivalence*** yields patterns of relationships among emergent roles as positions defined by patterns of relationship. See: Network-defined concepts in social behavior, Structural properties of graphs or networks, Equivalence, structural or regular.

Emergent rule. A rule of behavior that is not explicitly stated by participants in the behavior, but can be stated by network analysis. In network analysis, an emergent rule is observable as a recurrent structure in a time frame or as a regularity that plays out in time. A widely recognized example is **matrimonial sidedness (sides)**[11] that derives from a marriage practice of marital relinking in which the cycles of ties that connect spouses avoid having an odd number of male links (**uxori-sides**) or an odd number of female ties (**viri-sides**) or both (**cross-cutting sides**). The **equivalence theorem** for ***balance*** in signed graphs provides the ***micro-macro linkage*** between this practice and a relational model that approximates that of matrimonial moieties. Sides, while found in moieties, need not be named nor hereditary, but are a marriage rule that is emergent from behavior. See: Graph theory, Balance, Network-defined concepts in social behavior.

Emergent process. A process that is not recognizable or named in everyday practice but can be identified by network analysis. Process models derived from network analysis can take different forms, many of which are exemplified in this book. See: Complexity, Complexity theory, Network-defined concepts in social behavior.

Equivalence, structural and regular; Blockmodeling.[12] Nodes in a network are **structurally equivalent** if they are in the neighborhood of the same other nodes (White, Boorman and Breiger 1976). They are **regularly equivalent** if they are in the neighborhood of equivalent neighborhoods or by recursion, have equivalent relations with equivalent sets of others (White and Reitz 1983). In each case, an equivalence

blockmodel maps together equivalent nodes into a network image of positions that are related by carrying over the ties between nodes into ties between positions. See: Graph, Role relations, Structural properties of graphs and networks.

Exocohesion. A set of nodes in a graph has an exocohesive level k if there are k node-independent paths between every pair of nodes in the set, but not all the intermediate connecting nodes on these paths need be in the exocohesive set and may lie instead outside it. Exocohesion matrices are analyzed by ***hierarchical clustering***.[13] See: Cohesion, k-components, Structural properties of graphs and networks.

Fractality. Properties or behaviors that are fractal, like power laws, are self-similar at different spatial or temporal scales: For example, the appearance of the edge of a coastline at different resolutions, or of variation of stock prices at different time intervals. Complex systems often have fractal properties. One hypothesis is that fractal processes that result from interaction of two levels (a complex system), such as earthquakes at one level and randomly distributed frictional stresses along potential fault lines at a lower level that affects the production of the earthquake, usually have the signature of a log-log ***power-law*** distribution that is fractal or **scale-free** over a large range of spatial or temporal resolutions in which the logged magnitude varies linearly with the log of temporal frequency. Another two-level example is that while the growth of savings accounts according to fixed compound interest is not power-law, the rich get richer faster than others by moving successively larger amounts of capital to new investments that have increasingly higher returns. This dynamic is self-amplifying and produces the classical power-law **Pareto distribution** of the inequality of wealth. See: Complexity theory, Complexity, Power-law or scale-free distributions.

Graph. A set of ***nodes*** and a set of ***lines*** between distinct pairs of nodes. The exclusion of **loops** in this definition of graph is standard in ***graph theory***, and makes it easier intuitively to conceptualize some of the main theorems about the traversability of graphs. The terminology we use follows Harary (1969). A **signed graph** is one with two types of edges, positive and negative. A **multigraph** has multiple lines between nodes. A **digraph** has arcs but no edges, although arcs may be bi-directed and thus represented as edges.[14] A graph may have arcs and edges, but a **simple graph** has only edges. Harary's (1969) definition of graph is synonymous with simple graph, which he distinguishes from a digraph (directed graph) with directed edges (arcs). A (directed) **path** in a graph is an alternating sequence of nodes and (directed) edges that connects two nodes without repeated nodes or edges. A **semipath** from nodes u to v is a path whose edges may be arcs oriented in either direction. A (directed) **cycle** is the same as a path except that the endpoints are the same. A **semicycle** is a cycles whose edges may be arcs oriented in either direction. A **subgraph** is a set of nodes in a graph together with the lines between them.

Graph Theory: A qualitative or relational branch of mathematics (Harary 1969) dealing with formal definitions that build on earlier ones or on primitives, and theorems deriving from formal definitions. An **equivalence theorem**, for example, is one that proves that two nontrivially distinct properties of a graph entail one another (see: ***balance***, ***clustering***, *cohesion*). A number of our definitions refer to the mathematical property of an object that is **maximal** with respect to this property when there is no larger object within the context that contains it that has that property. This concept is used in many different context, including subnetworks and graphs that are maximal with respect to some property. See: *Node* and *line* (the primitives of graphs), Graph, Relation; Clustering and Curvature coefficients; Balance, Clustering and Ranking; Symmetry, Transitivity and Triad census; Cohesion, k-components, Edge betweenness, Exocohesion and Adhesion; Centrality, Centralization; Equivalence, structural and regular.

Hierarchical clustering analysis (HCA).[15] A method for showing hierarchical subsets of elements in a matrix or network in which all pairs of elements in each subset have a minimum {average, maximum} value. See: Methods of graph and network analysis, Edge betweenness, exocohesion.

Inheritance. A binding transfer of ***wealth assets*** or consumables to customary heirs after or anticipating a death. **Testamentary disposition** is the annulment of inheritance through substituting a written will left by the deceased. See: Marriage transfers of assets, Bridewealth, Dowry.

k-components.[16] A network can be decomposed into **k-components**: maximal subnetworks corresponding to each level of k-connectivity. These levels form **embedded cohesive hierarchies**. The **embeddedness** of a person in a network can be defined as the connectivity of the most cohesive k-component to which that person belongs. A 1-component of a graph is simply called **component**; **bicomponent** is a synonym for 2-component and **tricomponent** for 3-component. See: Cohesion and structural cohesion, Exocohesion, Structural properties of graphs and networks.

Line. A relation between a pair of ***nodes***. Its two defining **endpoints** (endnodes) are **incident** with the line. A line may be directed or undirected. An undirected line is an **edge** and an undirected line an **arc**. A **loop** is a special type of a line that connects a node to itself. Lines may be **multiple** between the same pair of nodes. See: Graph.

Lineage. A corporate group whose members share a common ancestor, usually based on unilineal descent with members having rights to common ***wealth assets***, including inheritance, and statuses. An **ambilineage** is a lineage whose members share a common cognatic ancestor and affiliate either through their father or mother but not both. A **sib** is a single lineage distributed across multiple communities. In preference to the term **segmentary lineage** that has connotations such as spatially fixed segments that derive from Evans-Pritchard's (1940) description of the Nuer, we use the term **segmented lineage** for descent groups in which minimal lineages are embedded segments of minor lineages and minor lineages are embedded as segments of major lineages. See: Descent, Descent group, Clan, Agnatic tie, Uterine tie, Cognatic tie, Unilineal, Modes of reckoning descent.

Marital relinking. The term used by European ethnographers to refer to marriages where the families of bride and groom are already linked by kinship or marriage (Brudner and White 1997). Subtypes: see Affinal and Consanguineal relinking.

Marriage Transfers of Assets. Marriage transfers are consumption goods and/or ***wealth assets*** transferred as part of marriage given as gifts (as distinct from rights in inheritance) or in exchange for other rights transferred at marriage. See: Inheritance, Bridewealth, Dowry.

Matrilocal. A ***residence pattern*** where a married couple goes to live in the household of the husband's parents. Synonym: **Uxorilocal**, but contrastive in Murdock's (1967) terminology with residence with the wife's matrilineage, which he terms ***matrilocal***. See: Residence, post-marital, Patrilocal, Neolocal.

Methods of Graph and Network Analysis. There are methods for analysis of each of the local network properties such as ***balance***, ***clustering***, ***symmetry or reciprocity***, ***transitivity****,* or ***ranking*** and other structural properties such as **blockmodeling**, ***cohesion***, ***centrality***, and so on. The introduction to Pajek software by de Nooy, Mrvar and Batagelj (2003) provides instructions to students that would allow most of the graphical representations and network analyses used in this book to be replicated (see endnotes). We use their definitions for graphs and networks *except where they conflict with those of Harary* (1969). See: Balance, Clustering, Clustering coefficient, Curvature coefficient, Cohesion, Centrality, Power-law, Triad census.

Micro-macro linkages. A **micro-property** of a graph or network is one that can be expressed as a property of nodes, neighborhoods of nodes, or traversals and recursions from nodes and their neighborhoods, e.g., through cycles that go out from a node or back. A **macro-property** in this context is a global property of a graph. An example is k-connectivity: the minimum number of nodes that along with their edges must be removed in order for it to become disconnected. A number of the **equivalence theorems** in graph theory deal with micro-macro linkages between properties, as for example: between (local) traversal and (global) **connectivity**; or between ***balanced*** (local) ***triads*** and balanced (global) signed graphs. See: Graph theory, Complexity theory, Balance, Clustering, Emergence.

Modes of reckoning descent. These are ways that descent is recounted orally, of which there are several main variants. The **depth first search** (DFS) starts from the topmost ancestor and works down (often through the line of highest rank) to the bottom, then return up this same line only to the point where there is another line to follow down, and so forth until all lines have been recounted. A **breadth first search** (BFS) starts from the topmost ancestor and takes up next the descendants in the following generation, then takes each in turn (often in order of highest rank) and their immediate descendants, repeating until all successive generations are exhausted. A **sibling set depth first search** imposes the recounting of sibling sets within the order of a DFS, that is, each time a lower node is taken the siblings of that node are taken up next (often in order of rank) before going on to the descendants of the initial node (see Fox 1978). The **ahnentafel** recording system for ancestries uses a reverse BFS in which ancestors are successively numbered in generations using the powers of two (2 parents, 4 grandparents, 8…) as the numbering system so that F is 1, FF is 3, FFF is 5, FFFF is 9, and numbers are standardized breadthwise to create an ancestry tree of bilateral ancestry where some names may known and others not. See: Descent, Descent group, Clan, Uterine tie, Cognatic tie, Unilineal, Modes of reckoning descent

Neolocal. A ***residence*** pattern where a married couple sets up their own household independent of either set of parents. See: Residence, post-marital, Matrilocal, Patrilocal.

Network.[17] A **network** is a ***graph*** or ***relation*** (of any type) together with additional information on its ***nodes*** or ***lines*** (including valued edges: Harary 1969): e.g., a **social network** implies a correspondence between a graph that represents individuals as nodes and social relations as lines. A **subnetwork**[18] is a subset of the elements (nodes, e.g., representing individuals) in a network together with all the information pertaining to the nodes and the lines between them. See: Graph, Tie, Reciprocity.

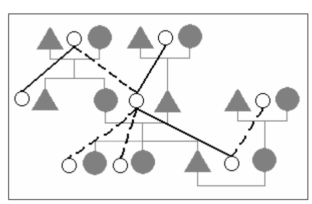
Network-defined concepts in social behavior. In addition to the distinction between **social organization**, "people getting things done by planned action . . . , action in sequences in conformity with selected social ends," and **social structure** as "those social relations which seem to be of critical importance for the behaviour of members of the society, so that if such were not in operation, the society could not be said to exist in that form" (Firth 1951:31,36), Chapter 1 argues for another layer of analytic concepts for persistent patterns that emerge out of interaction and become observable through network analysis. See: Emergent group, Emergent rule, Emergent role, Emergent process, Structural endogamy, Complexity theory.

Node. Synonym: **vertex**. The elements represented in a graph are points or nodes, connected by ***lines***. The **degree** of a node is the number of lines incident to it. See: Graph. In a **digraph** the **indegree** and **outdegree** of a node is the number of arcs incident to it and from it respectively. See: Graph, Network.

Norm, ideal. A cognized and culturally shared statement of how people should behave, not always corresponding to how people do behave. See: Prescription, Norm, statistical.

Norm, statistical. A rule of observed behavior and possibly a hierarchy of subrules for exceptions. See: Norm, ideal.

P-graph.[19] In a genealogical network represented as a p-graph, couples or unmarried individuals are identified with the nodes, and lines are drawn between each node identified as a parent or parents and every other node identified with a corresponding



daughter or son. Two types of lines can be distinguished, one for daughters and one for sons. When a person has multiple marriages, each marriage has a line to that person's parental node. If we consider the underlying graph, subnetworks with ***structural endogamy*** correspond to emergent **cohesive groups**. In the illustrative graph above the lines between the open nodes are those of the genealogical p-graph and they form a tree. If the two women to the upper right in the genealogy (dark circles) were sisters, however, a p-graph cycle would be formed where one of the men would have married his aunt. such cycles may overlap to form **bi-components** that define the boundaries of structural endogamy. See: Cohesion, k-component, Structural endogamy.

Patrilocal. A ***residence*** pattern where a married couple goes to live in the household of the husband's parents. Synonym: **Virilocal**, but contrastive in Murdock's (1967) terminology with residence with the husband's patrilineage, which he terms patrilo*c*al. See: Residence, post-marital, Matrilocal, Neolocal.

Power-law or scale-free distributions. For a technical understanding of processes that are scale-free and governed by power laws, and the importance attached to them, consider variables x and y as some underlying quantities governed by deterministic growth or decay equations with constants A, B, r and α (alpha) that stipulate how y is dependent on variations in x. In a **linear relationship** $y=A + B\cdot x$ where A is an initial value, a positive B is an additive growth constant (e.g., y=miles traveled, B=miles/hour and x=hours traveled, with A=0) and a negative B is the rate at which y declines. In an **exponential relationship** an initial value A is governed by a fixed rate r of growth or decay is raised to successively higher powers corresponding to unit intervals (x) in time, with result $y = A\cdot(1+r)^x$. E.g., y=savings balance, A=initial deposit, r=interest rate/year, x=years invested. Hence $\log(y) = \log(A) + x\cdot\log(1+r)$: log(y) varies with x. In the continuous case, $y=A\cdot e^{k\cdot x}$ where e=2.718 is the base constant of the natural log, denoted ln, and k=ln(r) is the natural log of r, the power to which e must be raised to get r. Hence $\ln(y) = \ln(A) + k\cdot x$. Exponential growth curves begin slowly and accelerate with x (x is time in the savings account example). Many mechanical rules and natural processes have exponential decay, such as radioactivity or elimination of drugs in the body, so the feature of a 'half-life' or characteristic scale can be a fortunate one: E.g., radioactivity and pollution dissipate rather than linger. Similarly, because the resale price of a car decays exponentially, businessmen trade in their cars early on, before the characteristic time scale of value recovery is exceeded. In a **power-law relationship** where

A is an initial value and α is the power constant, $y=A\cdot x^{\alpha}$. Hence $\ln(y) = A + \alpha\cdot\ln(x)$. The power law rises or falls more quickly at lower values of x compared to the exponential but changes more slowly at higher values, hence 'fat tail' decay and more 'fat tail' dampening of growth. Only the power-law coefficient α is **scale-free** in the sense that it is not affected by multiplication or division of x by an arbitrary constant. For every doubling of the energy in an earthquake (x), for example, the frequency (f or y) is about four times less, regardless of the measurement scale for energy: Energy = $A\cdot f^{-2}$ where f is frequency, or equivalently f = Energy^2/A. The scale-free property does not hold for linear relationships: if we change the units for measuring x from hours traveled to minutes traveled, we must adjust B accordingly in our example. Similarly for exponential relationships: if we change x from years to months in computing cumulative interest on savings, we must adjust r accordingly. This means that if there is a power-law relationship between x and y, no matter how you measure interval variable x, you will always get the same alpha. Power-laws thus define **universality classes** defined by alpha, which explains why physicists and biologists attach so much importance to them (see for example the West, Brown and Enquist 1997 general model for allometric scaling laws in biology). That power-laws are scale-free also means that a special theory is not needed to account for phenomena governed by them but at different scales, such as large and small earthquakes. A special branch of a theory of segmentary lineages might not be needed to account for big segments as opposed to little ones nor to account for FBD marriage in a segmentary lineage system if the system has **fractal** properties governed by power-law processes. Power-laws, unlike savings accounts, often imply that the short-term past is no guide to the long-term future. Wealth, as opposed to savings, has a power-law dynamic if the relationship of wealth (x) to wealthy (f, a frequency) produces such differences as the rich get richer, i.e., at an accelerating rate of increase proportional to existing wealth. While the rich get disproportionately richer, however, savings accounts exist only on a characteristic scale because exponential decay by a constant γ of the frequency f(S) of savings accounts of size S, $f(S) = S\cdot e^{-\ln(\gamma)\cdot S}$, reaches a limiting account size after which no savings accounts are expected to appear in a finite population. An exponential process or distribution is not scale-free because while rates of change are constant, the absolute differences in growth or decline are accelerating. In contrast, the scale-free properties of power law phenomena are **self-similar** or fractal in their constant parameter α, the constant log-log slope of their distributions over different orders of magnitude of the phenomena. See: Fractal, Complexity, Complexity theory, Scatterplot analysis, Self-organization and SOC.

Prescription. An ideal norm that purports to allow no deviation of actual behavior from a stated rule. See: Norm, ideal.

Ranking, ranked digraph. A balanced or clustered digraph is **ranked** when the partitioned sets can be arranged in a partial order from lower to higher ranks so that arcs (directed lines) go from lower sets of nodes to higher ones. See: Triad census (for computation), Balance, Clustering, Signed graphs, Structural properties of graphs and networks.

Reciprocity. A repetitive pattern in a network or graph in which ties are directed but many ties are reciprocal. This corresponds to the concept of reciprocal exchange, but at minimum, as used in defining the property of curvature, is a minimal indication of mutual recognition. See: Symmetry, Curvature coefficient, Structural properties of graphs and networks.

Relation.[20] A (binary) relation is a ***graph*** with the addition of loops (see: ***line***). A **multiple relation** has multiple lines between nodes. A **directed relation** has arcs but no edges (although edges may be bi-directed and thus represented as edges). A relation may have arcs and edges, but a **simple relation** has only edges. Graphs and relations may be equivalently represented by a **matrix** in which columns represent nodes, arcs, edges or loops are represented by ones, and their absence is represented by zeros. Operations on the matrix will have corresponding operations defined on the graph or relation. See: Graphs, Tie.

Residence, post-marital: Where a married couple goes to live after they marry. There are many other alternatives than neolocal, matrilocal and patrilocal, the three given here, each having many possible subtypes and potential difficulties for classification of households! (see Skyhorse 2003). See: Residence, post-marital, Matrilocal, Patrilocal, Neolocal.

Role Relations. Observed social behaviors associated with norms stated by members of a group. See: Equivalence, structural and regular, Norm.

Scatterplot analysis.[21] When trying to estimate growth or distributional coefficients from empirical observations we can use ordinary least square estimates of best fit to a straight line in scatterplots of the variables x and y, the difference among the plots being that **linear** distributions are straight lines in ordinary unlogged scatterplots; **exponential** distributions are linear only in semi-log plots; and ***power-law*** distributions are linear only in log-log plots. See: Power-law or scale-free distributions, Methods of graph and network analysis.

Self-organization and SOC. The most studied problems in self-organization involve those phenomena that have the ***power law*** or **scale-free** properties of self-similarity at different levels or magnitudes of organization. Their study requires attention to how they are tuned by criticality parameters or **tipping points**. In one class of problems, the scale-free or self-organizing properties appear as a critical point is reached, and the power-law coefficient α can be measured accurately only at the closest proximity to that point. Other phenomena, called SOC for **self-organized criticality** (Bak 1996), appear to be at criticality or in general can be tuned to a relatively stable state of which power-law distributions are a normal feature. These phenomena include certain classes of kinship networks (White and Houseman 2002), including those studied here. See: Fractal, Complexity, Complexity theory, Power-law or scale-free distributions.

Signed graphs.[22] These are multigraphs with two types of edges, termed **positive** and **negative**. **Equivalence theorems** for ***balance***, ***clustering*** and ***ranking*** apply to signed graphs. These theorems also apply to a network for which reciprocated and unreciprocated ties are coded as positive and negative edges. See: Graph, Balance, Clustering, Ranking, Structural properties of graphs and networks.

Structural Endogamy.[23] A maximal subset of families in a genealogical network in which each pair is linked through two or more completely distinct ties of affinity or descent. Derived from the more general concept of cohesion and the theory of graphs (White and Harary 2001) in such a way that the boundaries of **structurally endogamous** groups are emergent from a pattern of relationships in the network that is accurately identified as a **bicomponent** of a ***P-graph***. See: Network-defined concepts in social behavior, p-graph, k-component. **Categorical Endogamy**, in contrast, is marriage among a set of people characterized by their attributes, such as nationality, ethnicity, social or economic class, region or religion.

Structural properties of graphs and networks. Structural properties of graphs or networks are those that derive from patterns of relationships. See: Reciprocity, Symmetry, Balance, Clustering, Ranking, Triad census, Cohesion and structural cohesion, k-components, Exocohesion, Centrality, Centralization, Edge betweenness, Equivalence, structural and regular.

Symmetry.[24] A digraph or relation is ***symmetric*** when a directed lines from node u to v entails one from v to u. A graph is symmetric by definition. See: Graph, Structural properties of graphs and networks.

Tie. A set of relations between nodes in a (e.g., a social) network that can be represented by lines in the graph of the network and for which there is additional information about the nodes and their relations. A **simple tie** is a single relation; a **multiplex tie** is one with multiple relations.[25] A tie between u and v in a social network is **reciprocal** when there is evidence that u gives to v and v gives to u, without an *a priori* constraint of symmetry. Ties in a subnetwork are ***transitive*** when, for each triple, u, v and w, a tie from node u to v and from v to w is always accompanied by one from u to w (see ***Triad census: transitivity***). See: Network.

Tipping Point. When tipping-point thresholds are passed in a network or field internal to a complex system such as connectivity among the nodes, critical density or alignment, the global properties of the network or field change qualitatively and can pass on this emergent or structural change to a more aggregate level in the system of which the network or field is a component. See: Complexity theory, Self-organization and SOC.

Transitivity. A digraph or graph is **transitive** when for any subset of three nodes {u,v,w}, a pair of (directed) lines from node u to v and v to w entails one from u to w. See: Graph, Structural properties of graphs and networks, Triad census.

Triad census, properties of triples.[26] A **triple** is a subnetwork of three nodes in a network and their ties (edges, arcs). A triple is **complete** when each pair of its nodes are an arc or and edge, or, in a social network, a tie. There are 15 other possible patterns of ties in triples. A **triad census** of the frequencies of triples with different properties allows the local structural properties of a network to be estimated (see: ***reciprocity***, ***balance***, ***clustering***, ***transitivity***, and ***ranking***). See: Graph, Structural properties of graphs and networks.

Unilineal. A rule of descent through agnatic or uterine ties. An **ambilineal** descent rule is operative in an ambilineage. **Bilateral** descent is reckoned by the cognatic principle, i.e., through males and females. See: Descent, Descent group, Clan, Uterine tie, Cognatic tie, Modes of reckoning descent.

Uterine tie. A relation between two descendants of the same ancestor traced only through females. Synonym: **Matrilineal.** A **matrilineage** is a corporate group whose members share uterine descent. See: Descent, Descent group, Clan, Agnatic tie, Cognatic tie, Unilineal, Modes of reckoning descent.

Wealth-asset. An asset, distinct from consumption goods, that must (a) possess a capacity to grow in value, number or size, (b) generate a flow of consumption benefits to those holding the rights to the wealth-asset, (c) be scarce in the sense that marginal increases in its growth must have a positive valuation and not constitute a surplus for which there is motivation for disposal, and (d) be exploitable over an indefinite time period by a multi-generation group linked by inheritance rules that holds rights to its accumulation over that period (Bell 1998, 2002:16-17). See: Marriage transfers of assets, Inheritance, Bridewealth, Dowry.

Further Reading

discussions of kinship analysis are found in Fox (1979) and Keesing (1975), of centrality in Freeman (1979, 1980), of structural cohesion in Girvan and Newman (2002) and Moody and White (2003) and of network topology and curvature in Eckmann and Moses (2002). Solé and Goodwin provide an overview of theory, method and examples for the study of complex forms of organization in social and biological systems. There are several general treatments of network methods (Degenne and Forsé 1997, Scott 1991, Wasserman and Faust 1994) with two main computer packages currently in wide use (Batagelj and Mrvar 1998, de Nooy, Mrvar and Batagelj 2003, Borgatti, Everett and Freeman 1992a,b). White and Houseman (2002) present a summary in more technical and theoretical terms of the significance of the findings of the present study for understanding complex system dynamics in social organization. They review the literature on small worlds, including the seminal work of Watts and Strogatz (1998) and navigability in small worlds (Watts, Dodds, and Newman 2002), on which our modeling of segmented lineage system is based.

Notes to the Glossary

[1] This web site, the Glossary to White and Johansen's *Network Analysis and Ethnographic Problems: Process Models of a Turkish Nomad Clan,* is periodically updated to improve the quality of instructional material in the endnotes and to note changes in software implementation.
[2] [Pajek Main menu:] Draw>Draw Partition, [Draw menu:] Layout>Energy>

Fruchterman-Reingold>2D or 3D, and [Draw] Layout>Energy>Kamada-Kawai>2D or 3D.

[3] Finding the best global fit to a model of balance for a network with positive and negative relations is not a problem undertaken in this book but detailed instructions are contained in Chapter 4 of de Nooy, Batagelj and Mrvar (2003). For applications to sidedness in kinship networks see Houseman and White (1998a,b). See the entry of the Triad census for local fit to the balance model.

[4] [Main] Net>Partitions>Degree and Net>Vector>Centrality>Betweenness or >Closeness compute the centrality measures for nodes. Degree are computed by Pajek centralities for up to one million nodes and closeness and betweenness centralities for up to ten thousand nodes. Another measure, computed by UCINET, is flow centrality (Freeman, Borgatti and White 1991). If each edge in a graph has a transport capacity of one unit, the flow centrality of a node is the percentage of the total amount of flow between all pairs of nodes that is not reduced when that node is removed from the graph.

[5] Eigen centrality is computed in the UCINET program package.

[6] Automatically computed in both the UCINET and Pajek programs when centrality scores are calculated.

[7] See endnote for the entry on Balance, where the same procedures apply.

[8] [Main] Net>Components>Bicomponents with default size set to 3 or more identifies sets of nodes with connectivity 2 or more. Tricomponents have yet to be implemented in current network packages (but see edge betweenness).

[9] Edge betweenness is computed in the UCINET program package. Hierarchical clustering of dissimilarity scores may be applied to show cohesive groups.

[10] The best options for matrix-based analyses of networks are found in UCINET.

[11] See endnote for the Balance entry.

[12] The most flexible options for blockmodeling using different criteria for equivalence mappings of different sets of nodes are found in Pajek, but these require advanced study of specialized articles. These techniques are not used in the analyses in this book.

[13] See White and Newman (2001). UCINET's point cohesion calculator and hierarchical clustering are useful for exocohesion analysis.

[14] Pajek options [Main] Net>Transform>Arcs→Edges>Bidirected only.

[15] UCInet's Network>Cohesion>Maximum Flow or Point Connectivity options automatically perform a hierarchical clustering analysis of a matrix of pairwise connectivity values.

[16] Implemented in NetMiner (see Moody and White 2003).

[17] The simplest coding of a network in Pajek, say for a four node directed cycle has the following format in a simple text file:

```
*Vertices 4
1 "label 1"
2 "label 2"
3
```

4
*Arcs
1 2
2 3
3 4
4 1

[18] Given a partition on the nodes of a network, or a cluster with selective numbers for a set of nodes, [Main] Operations>Extract from Network>Partition or >Cluster will extract a subnetwork according to the user's specification of the node set.

[19] Available at http://eclectic.ss.uci.edu/~drwhite/pgraph/pgraph.html, the pgraph program Ego2all.exe converts genealogical data from the text-file format described in Chapter 1 to formats for all the major types of kinship analysis software. Text-file formatted datasets on genealogical networks in over fifty societies are available at http://eclectic.ss.uci.edu/~drwhite/PDATASET.htm for use with the conversion program. This provides a comparative database for the strictly genealogical aspect of kinship networks.

Pajek's [Main] File>Network>Read uses the p-graph format suitable for network analysis as the standard default for reading databases in *.GED formats used by commercial and freeware genealogical programs and produced as well by Pgraph software.

[20] Pajek and UCINET network analysis packages are capable of analyzing relations (containing loops) and not just graphs, and of course, analyzing the attributes of nodes as well.

[21] For scatterplot analysis network variables are typically exported to Excel spreadsheet columns and then graphed using the scatterplot option

[22] In signed graph analysis using Pajek, the data coding (see endnote for Network), some of the lines are assigned negative values and others positive values, e.g., where a value is assigned after the numbers for node pairs:
*Arcs
1 2 -1
2 3 +1

[23] [Main] Net>Components>Bicomponents with default size set to 3 or more identifies blocks of structurally endogamous marriages for a genealogical database in p-graph.

[24] [Main] Transform includes options to convert >Arcs→Edges or Edges→Arcs.

[25] [Main] Transform includes options to >Remove>Multiple lines in various ways that reduce them to simple lines.

[26] [Main] Info>Network>Triadic Census. The output is ordered to facilitate evaluation of local properties of balance, clustering and ranking.