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To our families

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II.

Linking the Social Brain to the Social World through Network Connections

Bernice A. Pescosolido

The Human Genome Project (HGP) was expected to change the world of medicine and science. It did. The mapping of human DNA, with a working draft by 2000 (International Human Genome Sequencing Consortium, 2001; Venter et al., 2001) and a complete map by 2003 (International Human Genome Sequencing Consortium, 2004), was achieved in record time with many important discoveries, but at least one stunning conclusion: the nature-nurture debate was now obsolete.

While this was a widely anticipated outcome of the Human Genome Project, the reasons for that conclusion were at least partially unexpected. The result was not conquest but "consilience" (Wilson, 1998). The HGP did not produce the "book of life." The studies that followed in the next decade revealed the limited predictive power of DNA, in and of itself. In response, they brought to the fore the role of RNA and epigenetics, once considered the epiphenomenal "junk of nature." As "the markings on genes that program their function" (Szyf, quoted in Lee, 2009) but do not involve a change in the nucleotide sequence itself, how methylation-demethylation and histones come to be, what they do, and how and whether they are passed from generation to generation pointed increasingly to gene-environment interactions (GxE; see Bird, 2007). The knowledge of the now-separate disciplines would have to come together to arrive at a more holistic understanding of the complicated interactions that produce human behavior, including health and illness.

As E. O. Wilson (1998, p. 8) had predicted, this linking of "facts and fact-based theories across disciplines to create a common groundwork of explanation" became the flashpoint of new directions and the centerpiece of National Institutes of Health's Roadmap (Zerhouni, 2003). The HGP pointed to the environment more directly than anyone, including many social scientists, had supposed. In the first decade of the twenty-first century, some of the best scientists in the United States concluded that "the relations among genes, the brain, and social behavior have complex entanglements across several different time scales," leading to "increasing appreciation that social information can alter gene expression and behavior" (Robinson, 2004, p. 399).

Here, I argue that consilience, more recently expressed as transdisciplinarity,[1] requires (1) three fundamental understandings—biological foundations, biological embedding, and social embeddedness—and (2) a framework linking them. Together, they serve as the platform to facilitate cross-communication across the natural, social, behavioral, physical, medical, and public health sciences that 100 years of development *within* each of these traditions has downplayed. I leave the first fundamental understanding to those who know it, but I describe the latter two and end by suggesting one possible new framework, the Social Symbiome. It draws from a Networks and Complex Systems (N&CS) science approach, which offers enough of a shared perspective and language to deconstruct the "Tower of Babel" that plagues efforts at serious integration of insights across the disciplines (Pescosolido, 2006, 2011; Pescosolido et al., in press).

As the Institute of Medicine (IOM, 2006) noted, one of the basic challenges that faces transdisciplinary integration lies in the scores of factors and forces that the social and behavioral sciences bring to the table regarding human health and development. I argue that networks can serve as a prime organizational vector of transdisciplinary integration that can narrow those possibilities. Finally, though I draw on examples across health problems, I often focus on issues surrounding mental health and substance abuse, targeting suicide as a key research question. The concern with suicide has a long research tradition in both the medical and the social sciences. In fact, understanding how such a private act is patterned by larger social forces such as religion and marriage supplied sociology with its empirical foundation (Durkheim, 1897/1951; Pescosolido, 1994). These issues, clearly connected to the brain, resonate across the sciences and provide a rich set of empirical findings that, together, support the development of an approach linking biology and society. Yet, they also raise challenges in schizophrenia and other mental disorders of adaptation to social context, for example, as to how scientific teams integrate the best of what they bring

to the proverbial transdisciplinary table (van Os et al., 2008; van Os et al., 2010).

The Nature of the Social

Powerful support for linking the social brain to the social world through network interaction comes out of the research agenda on mice, stress, and maternal behavior (see Meaney, 2001, for a review). Looking at the psychosocial development of mouse pups, researchers in Canada have documented that the network tie between mother and pup is critical to adult mouse "mental health." Reminiscent of the early Harlow monkey studies on attachment and neurosis, those pups with attentive mothers grew to exhibit behaviors more consistent with a healthy adult mouse. They demonstrated better spatial learning, had less fearful demeanors, and, for both males and females, even went on to demonstrate better parental care themselves (see de Jong et al., 2012, on males). Those without such maternal attention were characterized with "abnormal neural and behavioral development" (D'Amato et al., 1992). In brief, mother mice that groomed and licked their pups raised pups that were more "successful" as adults. The nature of the maternal care bond modified the expression of genes that regulate the behavioral and neuroendocrine responses to stress (i.e., the pups produced less stress hormone). Researchers linked these responses to a chemical change, specifically a group of molecules, a methyl group, which attached itself to the control center of genes regulating stress and, essentially, switched it off. This DNA methylation, a chemical coating of the genes, results from the social behaviors of mothers and alters the epigenome, endophenotypes, and phenotypes while leaving the genome intact.

In fact, according to Meaney and Szyf (2005), the mechanism through which detrimental environments "coat" the DNA structure occurs at a glucocorticoid receptor gene promoter in the hippocampal structure of the brain. Altered histone acetylation and transcription factors associated with nerve growth bind to the promoter. Further, DNA methylation changes glucocorticoid receptor expression because it modifies chromatin structure. Finally, by targeting these processes with drugs, the stress effects on the mice pups could be successfully reversed.

This example illustrates two key links between the social brain and the social world. The most obvious is the role of *biological embedding*—that is, how social factors and processes "get under the skin" to affect health and development. Yet, considering only that link is too simplistic. To move transdisciplinary integration forward, we must also understand and

incorporate the complexities of *social embeddedness*, how individuals are connected to layers of environmental structures, providing an understanding of context. Both are addressed below.

Biological Embedding

First coined by Hertzman (2000), this concept was developed to explain the nearly universal social class gradient in health. That is, across a wide spectrum of diseases and disorders, individuals with lower socioeconomic (SES) status have higher rates of morbidity and mortality across the life course. Hertzman hypothesized that, as an "emergent property" of the interaction between individuals' developmental, material experiences and psychosocial conditions, the brain is "sculpted" in childhood. This interaction conditions other immediate and prolonged interactions between defense systems and the brain. Indeed, research has revealed that children exposed to adverse psychosocial experiences, often associated with disadvantaged social position, show elevated disease risk in adulthood (Danese et al., 2011; Shonkoff & Phillips, 2000). From this, Hertzman proposed that theorizing, describing, and hypothesizing the biological mechanisms through which disadvantage translates into risk was critical. In particular, tying biological embedding to sensitive periods in the development of neural circuitry would show how environmental influences on both genetic variation and epigenetic regulation generate "socially partitioned developmental trajectories with impact on health across the life course" (Hertzman & Boyce, 2010, p. 329).

Thus, biological embedding alters biological processes caused by social experiences and circumstances and, in turn, either protects or predisposes individuals to health and disease. Because this "stamping" appears to be stable and long term and can be multiplied over time, individuals who are persistently in lower social class statuses can cumulate adverse effects over their development. This works primarily thorough four neurobiological systems that can create pathways to translate social experiences into biological effects (Hertzman & Boyce, 2010, p. 336). First, the hypothalamic-pituitary-adrenal (HPA) axis is involved in the secretion of cortisol, still considered a good biomarker of the stress response. Second, the autonomic nervous system regulates the production and release of neurotransmitters such as norepinephrine and other chemicals implicated across numerous brain disorders such as anxiety and depression (Higgins & George, 2007). Third, the prefrontal cortex affects memory, attention, and other executive

functions implicated in brain disorders from Alzheimer's disease to attention-deficit hyperactivity disorder (ADHD). Finally, the primitive amygdala locus coeruleus and higher-order cerebral connections influence skills central to social affiliation implicated in health problems from autism to schizophrenia (Barr & Kolb, 2007).

Biological embedding results from day-to-day experiences as well as exceptional traumas, producing cumulative advantage, disadvantage, or amelioration over time. In line with other recent views on susceptibility, ideas about biological embedding are nonlinear and nonspecific. That is, even similar environmental experiences can produce different health problems because they are embedded in complex interactions over time. Researchers studying genetic influences on mental illness, for example, no longer limit themselves to disease-specific phenotypes (e.g., parental schizophrenia linked to schizophrenia in offspring) but rather to a wide spectrum of psychiatric disease and disorders (i.e., examining a family pedigree that involves schizophrenia in parents for schizophrenia, bipolar disorder, depression, ADHD in their children, etc.; see Gottesman & Gould, 2005).

Some suggest that at the core of this process lie recurring, network-based interactions. Hertzman and Boyce (2010, p. 332), for example, see health disparities as a function of power differences that produce regular and routine *social interactions* marked by discrimination. In turn, such encounters translate into direct biological effects "at least partially attributable to differences in individuals' sense of identity, respect, and position within societies, small or large, marked by nonegalitarian structures and values."

Social Embeddedness

The last statement reveals why it is not enough to consider biological embedding alone, even as it stands as the necessary link between the biomedical and sociobehavioral sciences. An individual's "position within society," in and of itself, marks an entire range of psychological, social, economic, and cultural forces. "Societies, small or large," references a range of social groupings; in sociological terms, anything from the family and peer group to the nation-state and historical epochs. "Nonegalitarian structures and values" points to both vertical dimensions of social hierarchy and to deep cultural content.

The social environment is intricate, dense, and multifaceted. Elucidating the mechanism of biological embedding requires understanding the nature and range of social influence and the social structures that shape them. To

that end, social embeddedness offers one way to conceptualize and break down the connection between the social brain and the social world. As the degree to which social actors are enmeshed in social networks, this concept can be extended to include the overlap of social ties within and between social units. Introduced by sociologist Mark Granovetter (1985), it is derived from a social network perspective with early and deep roots in sociology and anthropology (Freeman, 2004) and with renewed vigor in an emerging "network science" (Barabasi, 2009). Seminal ideas that became the concept of social embeddedness were employed by Granovetter (1974) to describe how men's social networks shaped the process of acquiring jobs with better or worse salaries, benefits, and job satisfaction. The key here was that Granovetter hypothesized and provided empirical evidence that economic outcomes, in his case, were fundamentally influenced by social process and structures that were noneconomic in goals or content. Thus, social systems or levels are fundamentally bound up in one another. Social-network ties can have effects beyond their explicit purpose, and even "weak ties" play an important function, connecting different groups and sectors (Granovetter, 1983). Further, even the social and temporal embeddedness of social institutions themselves can be traced through individuals' personal networks (Cleaver, 2002).

Over time, social embeddedness has come to take on the wider meaning of how social actors, whether individuals (Wellman & Wortley, 1990), organizations (Aldrich, 2007), institutions (Tilly, 1984), or even nations (Beckfield, 2010), are inevitably and fundamentally tied into larger social environments represented by network connections. It is a dynamic process with networks as the mechanisms linking individuals and institutions across levels, time, and place. In health, social networks describe the nature of the community as well as individuals' access to and participation in rich, supportive, advantaged environments or decimated, difficult, and disadvantaged ones known to be associated with well-being or disease risk. A large body of research supports the critical role that human connections play in health, illness, and disease status (Kawachi, 2001; Pescosolido & Levy, 2002). In health care, networks describe the hopeful, compassionate, or distressing sterile climates and bonds formed within offices, hospitals, and systems. Social networks shape pathways to care (Pescosolido, Brooks-Gardner, & Lubell, 1998a; Pescosolido et al., 1998b). They shape the nature of provider communication (West et al., 1999) and influence health system change (Swan, 2009). Considered together, individuals', providers', and systems' health and illness "careers" (Pescosolido, 1991) are facilitated or impeded by the interaction of treatment and community networked systems.

Developing a Shared Framework Linking the Social Brain to the Social World

All science models, at this point, understand that microprocesses do not operate in a vacuum. The fundamental concepts of biology provide the foundation of behavior, including health and disease. The concept of social embeddedness sets multiple levels of the social world, viewing entire processes constituted and operating through social networks. Biological embedding represents the concept linking the social brain to the social world.

To offer a transdisciplinary framework linking biology, biological embedding, and social embeddedness, several conditions must be met. Such a theoretical scaffolding (1) considers and articulates the full set of contextual levels documented to have an impact in past empirical research; (2) offers a dynamic underlying mechanism or "engine of action" that connects levels, allowing for a way to narrow focal influences; (3) employs a metaphor and analytic language familiar to both social and natural sciences to facilitate synergy; (4) understands the need for and uses the full range of methodological tools from the social and natural sciences (Pescosolido, 2006); and (5) provides a tangible pathway to intervention, whether through medical treatment, legal policy changes, or community-based activism (Pescosolido, 2011).

What individuals know, how they evaluate the potential efficacy and suitability of a range of behavior, and what they eventually do are fundamentally tied to, negotiated in, and given meaning through social interactions. These draw from and are translated back to the individual as social experiences recorded on the genome. Cutting-edge approaches across the physical (Vespignani, 2009), biological (Sporns, 2011), medical (Christakis & Fowler, 2007), public health (Valente, 2010), and social (Liu, King, & Bearman, 2010) sciences support the network perspective as a potential solution.

Network models privilege one explanation—social interaction through and in network ties—providing a fundamentally different starting point and placing different priorities on sets of explanatory factors already found to be useful (Pescosolido, 1992). For example, in health care, the Network Episode Model (NEM; Pescosolido, 1991) took this approach in light of frustrations with the inability of existing individually focused and static models of help seeking to provide basic explanatory power. The NEM began with the premise that responding to illness or prevention is a phenomenon structured and given meaning through a social process managed by individuals' social networks in the community and the treatment system. Since individuals

In network terms, then, intergroup connectedness is seen as a major way that society affects suicide. For example, differences between Norway and Denmark's suicide rates have been traced to difference in social integration, and in Norway, where the level of integration among young men was in decline, suicide rates increased (Bille-Brahe, 1987; Institute of Medicine, 2002). The doubling of the suicide rate in Ireland from 1945 to the 1990s has also been seen as directly related to lower levels of regulation and integration (Swanwick & Clare, 1997). Using Granovetter's notion of social embeddedness, recent research has found that even the suicide attempts of "weak-tie" network members push at-risk youth toward more suicide/ideation (Baller & Richardson, 2009). In sum, social networks both create and "hold" culture—emotions, stress, values and beliefs, and action scripts.

Figure 11.1 provides a graphical rendering of Durkheim's theory translated into the current language and perspective of social networks (Pescosolido & Levy, 2002). Each dimension of group connectedness runs from dense to sparse in terms of network ties. When these two are considered simultaneously, four poles represent the kinds of network structures that predispose individuals to suicide. Specifically, when individuals exist in social structures with too little integration or regulation, the social net is loose or open, and there is little in the social structure to "catch" individuals when crisis destabilizes their equilibrium. In the face of challenge, social network ties provide an insufficient buffer and individuals "fall" through the net. Thus, the absence of network ties that provide support *or* oversight results in problems—disease, death, inadequate care, lonely neighborhoods, unmethylated stress-related genes, and so on. For Durkheim, location on the spatial network map with too little integration produced a state of egoism in the social structure, a higher egoistic suicide rate (disconnectedness at the aggregate level), or a greater probability of egoistic suicide (isolation at the individual level). For similar topographical reasons, but fundamentally different social reasons, locations characterized by underregulation also put individuals and societies at a similar level of risk. With networks that provide too little regulation, the social structure is in a state of anomie (normlessness), the individual is in a state of anomia (rootlessness), and the probability of suicide is also high. Both locations produce "diseases of the infinite" because they provide no grip in the societal safety net that supports people during times of individual or community crises.

Figure 11.1 also depicts problem locations in societies that are too regulated or too integrated. Here, social networks are overbearing and the safety net closes up. With no "give" to the social net, the domineering nature of social connectivity results in an inflexible, unsupportive social environment. Like the situation of "too little," the situation of "too much" has dire con-

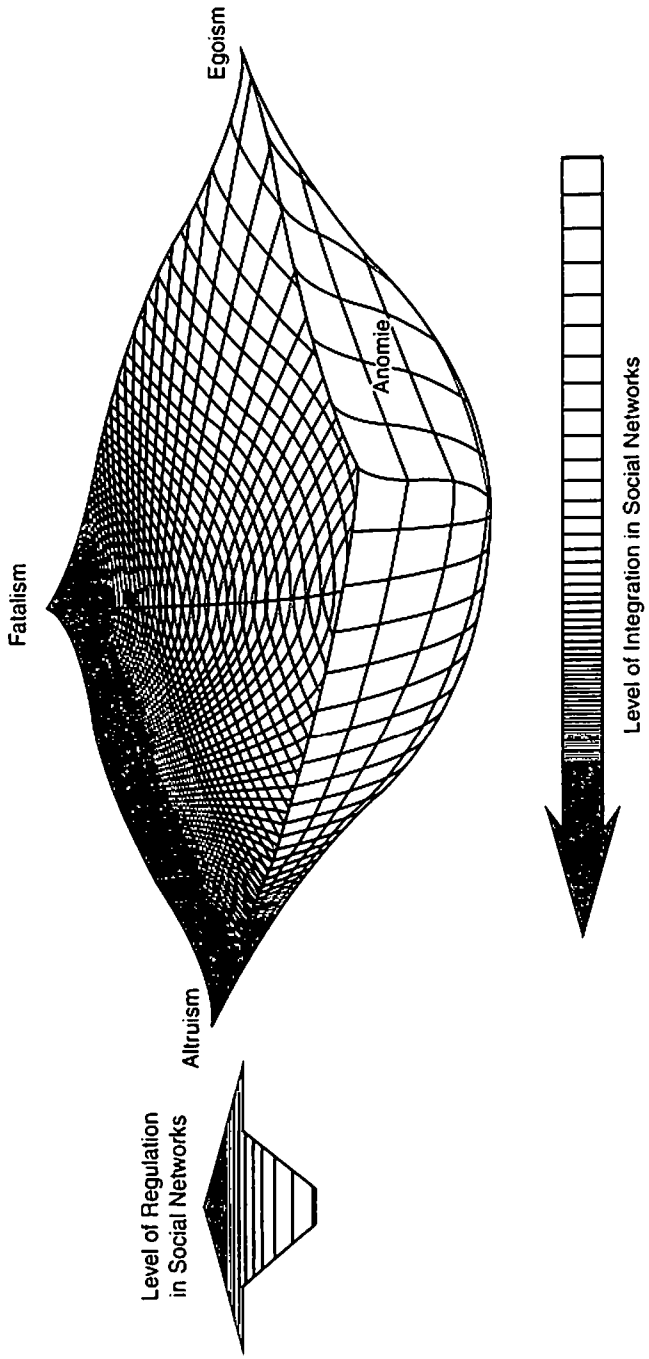

FIGURE 11.1. Theoretical predictive plane for a Network and Complex Systems (N&CS) science framework (adapted from Pescosolido & Levy, 2002; Institute of Medicine, 2002; reprinted with permission).

sequences. Confronting challenges in the context of an overintegrated social structure produces altruistic social structures and correspondingly altruistic suicide (e.g., war heroes, saints), while the overregulated location produces a fatalistic social structure with fatalistic suicides (e.g., mass cult suicides; Pescosolido, 1994). In both cases, the individual becomes fused with the group, losing individual identity and the capacity for independent decision making and self-protection.

The middle (or lowest point) in the social safety net offers the greatest support in the face of biological or social challenges. Here, social networks are optimal (i.e., moderate on both dimensions) and together result in the lowest number or rate of suicides. For example, the intersection of moderate levels of integration and regulation is thought to underlie the fairly consistent finding of lower suicide rates for married men. To use Durkheim's terms, men "profit" in marriage, at least in part, because their wives cajole, coerce, or demand that their husbands engage in healthier behavior, as well as provide the companionship and support more typically ascribed to marriage (Umberson, 1987; Umberson & Greer, 1990). As individuals fall on places on the net that are higher (e.g., more extreme values or amounts of marital regulation, as in domestic abuse), the predictions are more grave for suicide (see Kushner & Sterk, 2005, on an alternate hypothesis; Neeleman, 1998).

From Genes to Global Cultures

What is most crucial to understand about the net is that it does not depict what any one individual "has." Rather, it depicts a fixed theoretical space that describes the possible configurations and consequences of network structures. Biological and social systems have a network structure that predisposes or protects individuals from suicide. Individuals have stronger or weaker connections into those structures. Together, this constructs a personal world of social and biological influence. The IOM (2002) reports the heritability of liability to suicidal behavior to be somewhere between 30 and 50 percent. Both biological embedding and social embeddedness likely play important etiological roles in the remaining 50 to 70 percent.

In network imagery, membership in Durkheim's "societies" or "social groups" translates into sets of networks at different levels of aggregation. He considered country-level differences (e.g., Italy vs. England), organizational or institutional differences (e.g., family structures, religions), and individual differences (e.g., marital status) in integration and regulations. If

we then bring to the N&CS science new data on networks at biological levels (e.g., brain networks; Sporns, 2011), we end with six core systems, each with a theoretical prediction plane, modeled in infinite remission (i.e., a fractal structure; Abbott, 2001; Pescosolido, 2011; Pescosolido et al., in press). The community or "place," institutions or "organizations," the support system or "personal networks," the individual or "self," the biology or "body systems," and the molecular system or "genes" and "proteins" all shape pathways to health, morbidity, and mortality, as well as responses to them (see Duberstein et al., 2004, on support for multiple types and levels of social integration). The interconnections among these large, interacting units align directly with the basic definition of complexity theory and the potential of a network perspective to provide direction (Mitchell, 2009).

In sum, Durkheim's notion of the centrality of social interactions in understanding suicide corresponds to the primary starting point for an N&CS science framework linking the social brain to the social world. The nature of social interactions defines the mechanism underlying the impact of social structures and process. Taking it one step further, these mechanisms exist both within levels of the social and biological environment and also connect their influence across levels. Combining the theoretical specification at each level (Figure 11.1) with a consideration of the multiplicity of levels of society and biology that may work to influence health and health care produces the Social Symbiome (Pescosolido, 2011; Pescosolido et al., in press). Fleshing out this frame within and across levels and guidance by a focus on how one social influence—religion—has been implicated in suicide may facilitate understanding of how biological foundations interact with social embeddedness to produce biological embedding.

Key Research Question: How Does Religion Operate as a Prime Vector of Social Environmental Influence?

Religious groups represent one form of many natural "communities" dependent upon factors such as member socialization and participation (Gustafson, 1961; Tilly, 1984). According to social scientists, the potential protective or destructive power of religion depends on the ability of religious networks to provide a source of support and guidance. This is interwoven with the ability of religious groups to draw individuals to their activities and actually participate in a religious network (Collins, 1982; Pescosolido & Georgianna, 1989). For example, what differentiates religious groups in their ability to restrain or facilitate suicidal impulses lies in the degree to

which religions provide social and historical communities that provide emotional support and instrumental help. In Durkheim's original hypothesis on the role of religion in the transition to modern industrial society at the end of the nineteenth century, those who stood with Catholicism were seen as having a base of strong and continuing network affiliation located in the church and the wide range of other social institutions (e.g., hospitals and schools) that it controlled. Suicide rates in predominantly Catholic areas were relatively low because of the continued guidance (i.e., regulation) and institutional supports (i.e., integration) the church provided in the modern age. Those who affiliated with the more liberal religions resulting from the Protestant Reformation chose tolerance, free inquiry, and diversity. They traded emotional and institutional support and, in turn, faced greater psychological tensions, ambiguity, and ultimately higher suicide rates. This "one law" dominated much of the debate on religion and suicide over the twentieth century (Bankston, Allen, & Cunningham, 1983; Johnson, 1965). Research generally supported Durkheim's original claim but not without evidence to the contrary.

Reconsidering these ideas through a network translation of the more general proposition (i.e., religions with greater integration produce a lower suicide rate) rather than the specific hypothesis (i.e., Catholicism vs. Protestantism), we argued that three sociohistorical trends (secularization, ecumenicalism in the 1960s, and the post–World War II evangelical revival) had realigned religion in the United States (Pescosolido & Georgianna, 1989). In fact, we found that areas with greater representation of Catholicism and Judaism continued to post lower suicide rates. Further, Protestant religions labeled liberal, mainline, or institutional (e.g., Episcopal, Congregational) appeared to aggravate suicide, as Durkheim saw in Western Europe at the turn of the nineteenth century. However, Protestant religions classified as evangelical or conservative (e.g., Seventh-Day Adventists, Southern Baptists) seemed to have a protective effect on suicide, similar to Catholicism and Judaism.

In sum, the original *hypotheses* in Durkheim did not stand; yet, considered under a network frame, the general theory was supported. Conservative, evangelical Protestants are more likely to participate in religious activities and to name fellow congregation members as best friends than their liberal counterparts (Pescosolido & Georgianna, 1989; Stark & Glock, 1973). These churches are seen as strong, primary groups and "some of the most cohesive non-ethnic communities in the United States" (Roof & McKinney, 1987). To the contrary, mainline or liberal Protestants are seen as "dormant" because their studies document that adherents to these religious "societies" do not attend church frequently, often do not know one another, and participate in hierarchical church structures that translate into a passive role for members (Idler et al., 2003; Kelley, 1972; Quinley, 1974; Seybold & Hill, 2001).

There is an inherent complexity to religious influence that requires a rejection of a reductionist approach. The consideration of a number of components part and partial of the institution of religion represents a part of the self-organizing influence of religion on suicide. Specifically, the influence of religion depends on the context in which religions exist, on the network structure of the religious community, on the religious composition of any individuals' personal networks, and on the strength of the tie that binds the individual to a particular religious community. Religious communities are, in and of themselves, more or less likely to provide an integrative and regulative network of support. But, individuals can forge stronger or weaker ties with these religious communities and choose to participate (or not). For example, beliefs and values that shaped norms of behavior regarding suicide are deeply rooted in social networks that reinforce established ideas about right and wrong, as well as about appropriate ways to solve problems (Colucci & Martin, 2008; Pescosolido & Georgianna, 1989).[2] Thus, in line with Figure 11.2, social embeddedness in religion reflects the basic logic of complexity theory. There are large, interacting levels at which religion operates. Individuals, groups, institutions, and context, *together,* shape the religious landscape and create the social force on individual suicide.

New questions arise. Who in these highly Catholic areas had lower suicide rates? Was it just Catholics, or did the fabric of Catholicism, which had always included educational institutions from kindergarten to college, hospitals and social services, generally protect those who lived among the Catholics? And, were those who did commit suicide, even in these low-rate areas, *only* Protestants, members of other religious groups, those who were atheists, or even Catholics?

Only by considering multiple contextual levels of biology and society can we begin to unravel the etiological complexities of social and biological influences underlying suicide that are shaped by religious community. Table 11.1 provides examples of factors at each level that research has implicated in suicide. However, research attention has not been focused equally across levels, under a network perspective, or in some cases (i.e., molecular networks and religion) not at all. Given the reliance of social science on aggregated suicide rates, more research has been done on the upper levels on the Social Symbiome. Finally, given the focus of medical science on biological systems and disease, little research has brought social factors of any kind to bear across levels.

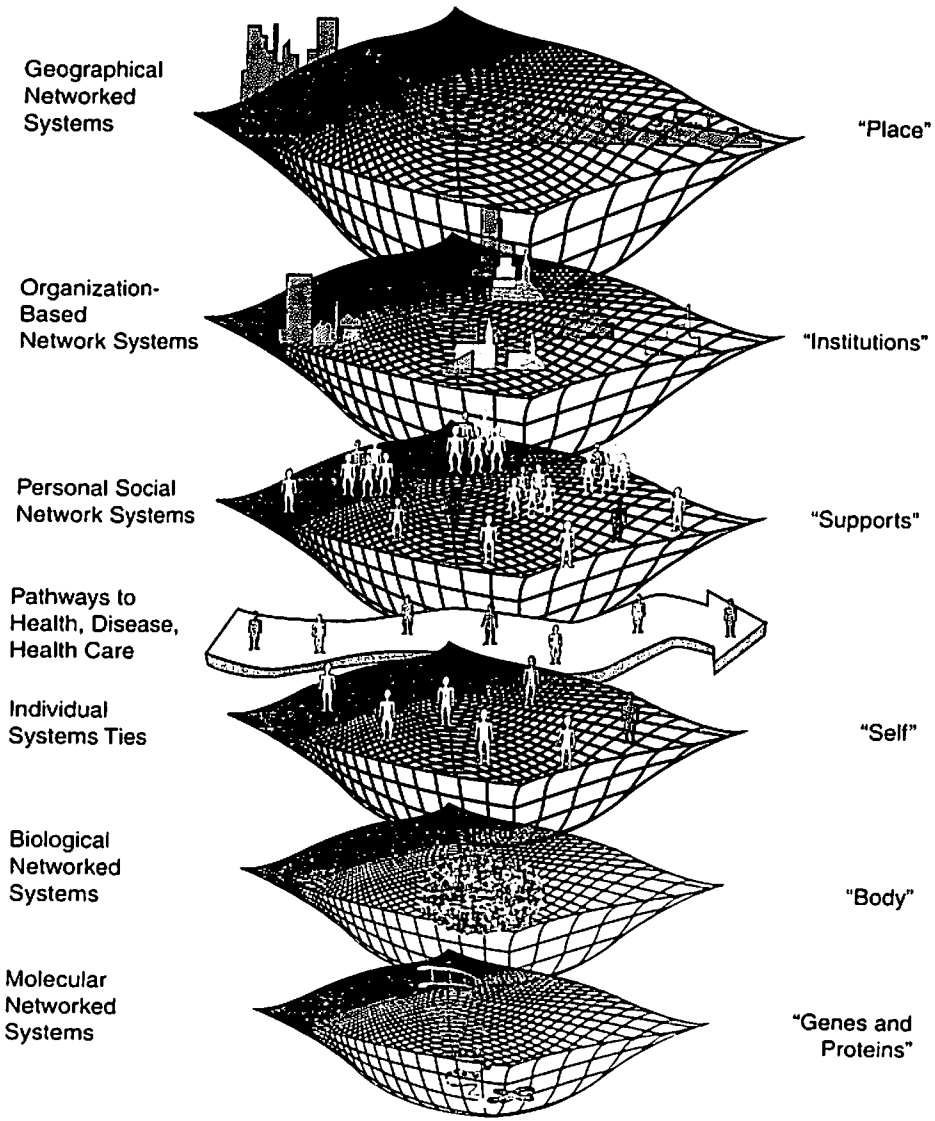

FIGURE 11.2. The Social Symbiome, based in Network and Complex Systems (N&CS) science, for human health, disease, and health care.

TABLE 11.1. Social and Individual Levels of the Social Symbiome and Examples of Religious Influences on Suicide

Network Levels	Examples of Religion Variables
Community Networked Systems	Presence of religious denominations Location of a religion in a historical hub of strength Religious homo/heterogeneity
Organizational Networked Systems	Integration and regulation in the "home" church, temple, congregation, etc. Religious pressure on medicolegal officials
Personal Networked Systems	Co-religious composition of friends, kin, network ties
Individual Ties w/o Networks	Religious affiliation and participation Religiously anchored meaning systems
Biological Networked Systems	Depression, other psychiatric diagnosis, HPA axis dysregulation
Molecular Networked Systems	No current research on religion
Cross-Level Interactions	Religious presence × divorce rate Catholicism × attendance Religious presence × health care system access Religious tie × depression, anxiety Religious tie × alcohol use Religious tie × divorce status Religious tie × stress Religious tie × HPA dysregulation Religious tie × inflammatory response

In the section that follows, a broad reporting of existing research is addressed, guided by the Social Symbiome. While some levels are sparse, the discussion ends with the rich potential in cross-level interactions suggested by current synergies.

The Community Network

Recent research on the presence of religious communities in an area and its suicide rate continues to demonstrate a clear effect of community-based religious networks. The proportion of conservative religious adherents *in a neighborhood* is negatively associated with individual-level suicide attempts (Maimon & Kuhl, 2008). Similarly, Van Tubergen and colleagues (2005) found that suicide rates in the Netherlands decreased as the proportion of church members within a given *municipality* increased. Indeed, they argue

that religious communities have a protective effect for all individuals in an area, whether or not they participate.

However, the larger context has also been implicated, as much by the absence of religion's effects as its presence. In Sweden, for example, Stack (1991) was unable to find an effect of religious affiliation on male or female suicide rates, and only limited support for an influence on youth. He argued that governments providing greater social connections (e.g., the Welfare State in the Nordic countries) may dilute the need for or influence of religion. Further, in the United States, the effects of religious affiliation appear to be more pronounced in *regions* of traditional historical strength for a particular religion. In these places, the opportunity to construct and maintain strong ties comes from the greater likelihood of locating coreligionists and the greater possibility of participating in organizations and institutions formed, supported, or otherwise assisted by religions with a longer and more pronounced presence. For example, while Catholicism's influence on suicide in the United States appears to be both large and consistently protective overall, its effect in the South, a region of relatively few Catholics, is to aggravate suicide. Similarly, in the Northeast, where the presence of Judaism has been historically and numerically strong, its greater presence also decreases suicide, but in all other regions of the country, Judaism is associated with an increase in suicide rates (e.g., in the South; Pescosolido, 1990; Bankston et al., 1983; Kowalski, Faupel, & Starr, 1987).

Finally, technology has created new forms of connected communities that escape geography. As Wellman et al. (1996, p. 213) noted early in the Internet age, "When computer networks link people as well as machines, they become social networks." They are seen as capable of creating and maintaining strong to weak ties; positive to negative ones; and religious, health, and friendship bonds (including ones relevant to suicide, suicide prevention, and suicide support groups; Eysenbach et al., 2004).

As listed in Table 11.1, these studies suggest the potential effect of the sheer presence of a religion, religious homogeneity, and contextual history.

Organizational Network Systems

Societies are made up of sets of organizations or groups that, together, form the basic social institutions—the family, religion, the economy, the educational system, the polity, and, particularly for health and illness, the health care system. While on one level, these help to shape the overall community context, each of these units can be conceptualized, per se, as having an integration/regulation profile. For example, the connectedness within any

individual's home church, temple, or mosque might matter, providing even more insight into the context under which religions might protect individuals from suicidal impulses. However, there has been little research at this level on religion. In Turkey (Eskin, 2004), we have a glimpse into the potential protective effects of institutional sectors affiliated with religion. Youth educated in religious versus secular institutions reported lower acceptability of suicide. Further, in the debate over the validity of official suicide rates, stronger ties of medicolegal officials to their communities have been seen as possible sources of bias in suicide rates. In the classic critique (Douglas, 1966), misreporting was directly tied to officials being pressured by religious or other community (e.g., local government) groups to conceal suicide rates. Individual and organizational differences in medicolegal systems have, indeed, been associated with rate reporting, though not always in the directions anticipated (CDC, 2008; Conwell, Duberstein, & Caine, 2002; Pescosolido & Mendelsohn, 1986; Timmermans, 2005; U.S. Public Health Service, 1999).

Other sets of social institutions, and the organizations that comprise them, have been prime research targets in suicide. While they do not implicate the influence of religion, the sheer dedicated research at this level calls for a consideration of the potential interaction of religious and other institutions (see bottom row of Table 11.1). For example, can a strong presence of religion moderate the consistent effects of other institutions? Here, a short description of the most robust influences on suicide rates is listed for such consideration.

The strength or weakness of the family institution in geographical areas has been routinely linked to suicide rates. In general, discord within families has been correlated with suicide, while parental and family connectedness produces the opposite effect, especially among youth (Cicchetti & Toth, 1998; Institute of Medicine, 2002, p. 3). In addition, health care systems can provide different levels of support in treatment centers and can set the connectedness between inpatient (organizational) and outpatient (community-based) services. For example, individuals discharged from mental health facilities, who had their outpatient care reduced at their last session, were documented to be at much greater risk of suicide in the weeks immediately following discharge (Institute of Medicine, 2002).

Personal Social Networks

While the levels above set the conditions for the likelihood that individuals can form particular kinds of network ties, any one person's set of networks

results in a unique configuration. Aggregate-level research suggests that the proportion of co-religionists in a person's network likely underlies the protective influence of particular religions (Pescosolido & Georgianna, 1989). At the individual level, involvement in religious activity has been associated with less suicide (Duberstein et al., 2004; Nooney, 2005). In fact, Brashears (2010) documents that an individual's ties with religiously similar others decreases feelings of restlessness and unhappiness. In general, those who enjoy close relationships cope better with various stresses, including bereavement, job loss, and illness, and enjoy better psychological and physical health (Institute of Medicine, 2002, p. 3). Conversely, individuals described as "rootless" or socially withdrawn are more likely than case-controls to complete suicide (Appleby, Shaw, & Amos, 1999; Nor, 2000; Trout, 1980).

The Individual

A long research line suggests that religious involvement works, in part, by shaping beliefs that can influence positive outcomes through "the inner experience of spiritual and religious feelings" (Anglin, Gabriel, & Kaslow, 2005; Colucci & Martin, 2008; Dervic et al., 2011; Greening & Stoppelbein, 2002). Religion also provides some individuals with a sense of meaning and purpose (Werner, 1992, 1996). Since conservative, evangelical denominations, for example, often require more frequent and active participation, individuals' religious commitment and beliefs have been tied together (Gearing & Lizardi, 2009; Stack & Wasserman, 1992).

Historically, however, individual and psychological explanations of suicide have focused squarely on conflicts, whether internal or social (see Jamison, 1999; Maltsberger & Goldblatt, 1996, for overviews). While religious involvement can result in conflict, the role of religion as a buffer of conflict and problems, including health, has been a mainstay of social science research. For example, belief in eternal life has been demonstrated to reduce the negative health effects of discrimination (e.g., Bierman, 2006) or anxiety (Inzlicht, Tullett, & Good, 2011).

Being divorced, separated, or widowed increases suicide, while being a parent, particularly for mothers, decreases suicide risk. Histories of mental illness, childhood maltreatment, and hopelessness have all been implicated in individuals' deaths by suicide (Abramson et al., 2000; Beck et al., 1974; Conwell, Pearson, & DeRenzo, 1996; Gonda et al., 2008; Institute of Medicine, 2002; Joiner et al., 2001; Weishaar & Beck, 1990). Again, these suggest possible interactions with stress across individual levels of the Social Symbiome (see bottom row, Figure 11.2).

Biology

Little research has been focused on the biological embedding of religious ties, participation, or effects (see Modai et al., 2002, on neural networks; Tai & Chiu, 2007). Most discussion on this topic focuses on the historical debates between evolutionary biology and religious teachings (e.g., Grinde, 1998), though some research has addressed biological pathways (e.g., Seeman, Dubin, & Seeman, 2003). For example, religious practices have demonstrated immediate effects on biological measurements such as blood pressure (Williams & Sternthal, 2007).

Further, while systems biology increasingly looks to network perspectives (Kreeger & Lauffenburger, 2010; Weiss, Yang, & Qu, 2006), this fairly new approach has not turned to biological predispositions to suicide. However, dysregulation of the HPA axis, as the primary stress response system, and variation in the functioning of the serotonergic and noradrenic systems have been implicated (Arango & Mann, 1992; Brunner et al., 2001; Goldsmith et al., 2002). The very recent establishment of a scientific journal, *Religion, Brain, and Behavior,* speaks to the growing interest in cross-level interactions that may prove useful in understanding the role of religion in suicide.

Molecular

According to the IOM *Report* (2002), the search for candidate genes for suicidal behavior has thus far been inconclusive. However, family studies (Statham, Heath, & Madden, 1998), particularly studies of adoptees from families with multiple suicides (Wender, Kety, & Rosenthal, 1986) and twin studies (Roy et al., 1991), have documented a sixfold increase among first-degree relatives. New avenues of research, though not directed to suicide, have moved to a network perspective. As Al-Shahrour et al. (2006, p. 472) note, "Genes do not operate alone in the cell, but in a sophisticated network of interactions that we only recently started to envisage." And, if we return to the fundamental concept of biological embedding, the potential impact of religion may lie with its influence on the epigenome.

The Complexity of Cross-Level Influences

Under an N&CS science perspective, a complete sketch of the Social Symbiome requires moving beyond an accounting of level effects. Interactions are evidenced. Targeting complex interactions with religion using

Temple came under greater scrutiny, frequent suicide drills and other extreme behaviors turned Jonestown into a "greedy group" (Coser & Coser, 1979), demanding total commitment and sliding the religious community to the fatalistic pole and over 900 deaths (see Pescosolido, 1994, for examples and detail).

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