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Introduction

The architects of the twenty-first-century digital age proclaim that *openness* is their foundational value. Their work is exemplified in movements that embrace open science, open access publishing, open source software, open innovation business strategies, open education, and so on.[1] President Barack Obama's "Open Government Initiative," announced on his first day in office in 2009, captured the collective spirit of these efforts: "We will work together to ensure the public trust and establish a system of transparency, public participation, and collaboration. Openness will strengthen our democracy and promote efficiency and effectiveness in government."[2]

The ideology of openness, as it is articulated and practiced in the early twenty-first century, would have surprised the critic and historian of technology Lewis Mumford. In his 1964 essay, "Authoritarian and Democratic Technics," he wondered: "Why has our age surrendered so easily to the controllers, the manipulators, the conditioners of an authoritarian technics?"[3] The advocates of openness, however, have not surrendered so easily. Instead, they sense the dawn of a radical, almost utopian transformation in which power hierarchies are flattened, secret activities are made transparent, individuals are

[1] Paul A. David, "Understanding the Emergence of 'Open Science' Institutions: Functionalist Economics in Historical Context," *Industrial and Corporate Change* 13 (2004): 571–589; Steven Weber, *The Success of Open Source* (Boston: Harvard University Press, 2004); Peter Suber, *Open Access* (Cambridge, MA: The MIT Press, 2012); Henry Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology* (Boston: Harvard Business Review Press, 2003); Michael A. Peters and Rodrigo G. Britez, eds., *Open Education and Education for Openness* (Rotterdam, The Netherlands: Sense Publishers, 2008).

[2] Barack Obama, "Transparency and Openness in Government," The White House, http://www.whitehouse.gov/open (accessed August 19, 2010).

[3] Lewis Mumford, "Authoritarian and Democratic Technics," *Technology & Culture* 5 (1964): 1–8. See also David E. Nye, "Shaping Communication Networks: Telegraph, Telephone, Computer," *Social Research* 64 (1997): 1067–1091.

empowered, and knowledge itself is democratized. They welcome innovation, thrive on diversity and change, insist on the sanctity of autonomy and freedom, and have an unqualified disdain for authority, restrictions, and gatekeepers.

The technological foundations that sustain this vision are digital: the Internet, the Web, and cellular telephone networks. These technologies together create a communication infrastructure that has the potential to evade the ability of established authorities to control, censor, or ignore. For individuals, "open" is shorthand for transparent, welcoming, participatory, and entrepreneurial; for society at large, "open" signifies a vast increase in the flow of goods and information through a global, market-oriented system of exchange. In the most general sense, it conveys independence from the threats of arbitrary power and centralized control. It is a discourse that speakers of the English language have found easy to adopt, given the common use of expressions such as "open-minded," "open to the public," and "open for business." "Openness" thus describes a marriage of technology and ideology and a fusion of technology, democracy, and entrepreneurial capitalism.

Although readers may believe that openness is inextricably linked to digital technologies born in the late twentieth and early twenty-first centuries, the purpose of this book is to explain the historical forces – creations and legacies of a pre-digital age – that forged our twenty-first-century open world. Some of these historical forces already have been the subject of a large number of academic and popular studies. Whether they describe the "rise of the network society," the advent of the "flat world," or the dawn of the "information age," many of these studies tend to celebrate American-style high-tech globalization. But the praise is not universal: critics rightly note that the world is not flat, that power asymmetries persist between various nodes in the network society, and that traditional bureaucracies such as national governments and industrial corporations have in many ways gained in strength and not withered away.[4]

Rather than join the chorus as a critic or champion of globalization in the twenty-first century, I pursue a historical objective in *Open Standards and the*

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[4] Manuel Castells, *The Rise of the Network Society* (Cambridge, MA: Blackwell Publishers, 1996); Thomas L. Friedman, *The World Is Flat: A Brief History of the Twenty-First Century* (New York: Farrar, Straus and Giroux, 2005); Louis Galambos, "Recasting the Organizational Synthesis: Structure and Process in the Twentieth and Twenty-First Centuries," *Business History Review* 79 (2005): 1–37; Louis Galambos, *The Creative Society – And the Price Americans Paid for It* (New York: Cambridge University Press, 2012); Alfred E. Eckes and Thomas W. Zeiler, *Globalization and the American Century* (New York: Cambridge University Press, 2003); John Gray, *False Dawn: The Delusions of Global Capitalism* (New York: The New Press, 2000); Phillipe Legrain, *Open World: The Truth About Globalization* (Chicago: Ivan R. Dee, 2004); Jack Goldsmith and Tim Wu, *Who Controls the Internet? Illusions of a Borderless World* (New York: Oxford University Press, 2006); Evgeny Morozov, *The Net Delusion: The Dark Side of Internet Freedom* (New York: Public Affairs, 2011); Stanley Fish, "Anonymity and the Dark Side of the Internet," January 3, 2011, http://opinionator.blogs.nytimes.com/2011/01/03/anonymity-and-the-dark-side-of-the-internet (accessed January 17, 2012); Nathan Ensmenger, "The Digital Construction of Technology," *Technology & Culture* 53 (2012): 753–776.

Digital Age: to explain how this state of affairs came into being. There already exists a conventional view, a theory of causation that permeates the literature: new technologies drive social change. A typical expression of this view may be found in Andrew Shapiro's 1999 book, *The Control Revolution*, whose argument was aptly summarized by its subtitle: "How the Internet Is Putting Individuals in Charge and Changing the World We Know." Another example may be found in the distinctive prose of journalist Thomas Friedman, who referred to new information technologies such as personal computing, Internet telephony, and wireless devices as "steroids" that are "amplifying and turbo-charging all the other flatteners."[5]

The consequences of all of this turbocharged flattening, of course, depend on one's point of view: when Google complained in 2010 that the Chinese government was censoring search results from google.cn, the Chinese newspaper *Global Times* defended China's right to protect itself from American "information imperialism." Google's high-minded defense of the freedom of expression was, the *Global Times* declared, a ruse – a "disguised attempt to impose its values on other cultures in the name of democracy."[6] The inherent contradictions and tensions bundled within terms such as "openness" and "transparency" have been further exposed by activists such as Chelsea Manning, Aaron Swartz, and Edward Snowden who put powerful institutions in uncomfortable positions by publicizing data that were intended to be secret. In other words, openness (and its ally, transparency) is easy to promote in rhetoric but more complicated to adhere to in practice.

One comes away from the popular accounts of high-tech globalization with an oversimplified, linear, and somewhat deterministic view of the relationship between technology and society: for better and for worse, the Internet and digital technologies have thrust an unprecedented era of openness on us. A more sophisticated and nuanced interpretation has, somehow, failed to find its way into the mainstream, even though the foundations for such an interpretation have been laid over the past fifty years by communities of historians, sociologists, and political scientists who study science and technology. Recent scholars, many of them contributing or responding to the theoretical framework of the "social construction of technology," emphasize the ways that technological artifacts, networks, and systems can embody and advance the cultural and political values of their makers. This literature, taken as a whole, has sharpened our understanding of the ways that technologies and societies are mutually constitutive – or, as historian Thomas Hughes summarized, how technological systems are "both socially constructed and society shaping."[7]

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[5] Friedman, *The World Is Flat*, 187.

[6] *Global Times*, "The Real Stake in the 'Free Flow of Information,'" January 22, 2010, http://opinion.globaltimes.cn/editorial/2010–01/500324.html (accessed January 17, 2012).

[7] Thomas P. Hughes, "The Evolution of Large Technological Systems," in Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: The MIT Press,

To comprehend the culture and technology of the twenty-first-century open world, we need to reject monocausal technological determinism, build on the work of social constructivists, and look closely at the "system builders" as well as at the social and institutional forces that shaped and constrained their actions. We should gain a better understanding of technology, but at the same time we must also come to terms with the organizational, economic, political, and cultural forces that do not exist independently of technology. Hence the central questions of this book: Who designed the digital foundations of open systems? How did they act upon their commitments to transparency, decentralization, and innovation? How are open systems different from previous systems and previous regimes of control, and how are they similar?

Two conceptual tools are useful to build historical explanations for these questions. The first, *ideology*, refers to a comprehensive set of ideas about the past, present, and future orderings of politics and society. I am aware that Marxist scholars and literary theorists (such as Raymond Williams) tend to use the term pejoratively to refer to illusions, false consciousness, and class conflict, but I do not use the term in that way. Instead, I follow historians such as Bernard Bailyn and John Kasson who use the term in a more neutral and descriptive sense to refer simply to worldviews or systems of meaning making. A definition in the *Oxford English Dictionary* also is helpful:

4. A systematic scheme of ideas, usu. relating to politics or society, or to the conduct of a class or group, and regarded as justifying actions, esp. one that is held implicitly or adopted as a whole and maintained regardless of the course of events.[8]

In the chapters that follow we will see many examples in which engineers, managers, and regulators made their ideological beliefs explicit in speeches, published articles, and private meetings. We will also see many other cases in which ideological beliefs were, as the *OED*'s definition suggests, held

1989), 51; Langdon Winner, "Do Artifacts Have Politics?" *Daedelus* 109 (1980): 121–136; W. Bernard Carlson, "The Telephone as Political Instrument: Gardiner Hubbard and the Political Construction of the Telephone, 1875–1880," in Michael Thad Allen and Gabrielle Hecht, eds., *Technologies of Power: Essays in Honor of Thomas Parke Hughes and Agatha Chipley Hughes* (Cambridge, MA: The MIT Press, 2001); Lawrence Lessig, *Code and Other Laws of Cyberspace* (New York: Basic Books, 1999); Janet Abbate, *Inventing the Internet* (Cambridge, MA: The MIT Press, 1999).

8 Raymond Williams, *Keywords: A Vocabulary of Culture and Society* (New York: Oxford University Press, 2003), 153–157; Clifford Geertz, "Ideology as a Cultural System," in *The Interpretation of Cultures* (New York: Basic Books, 1973); Hayden White, "Method and Ideology in Intellectual History: The Case of Henry Adams," in Dominick LaCapra and Steven L. Kaplan, eds., *Modern European Intellectual History: Reappraisals and New Perspectives* (Ithaca, NY: Cornell University Press, 1982); *Oxford English Dictionary*, 3rd ed., s.v. "Ideology, n." http://dictionary.oed.com (accessed January 17, 2012); Bernard Bailyn, *The Ideological Origins of the American Revolution* (Cambridge, MA: The Belknap Press, 1992), viii; John F. Kasson, *Civilizing the Machine: Technology and Republican Values in America, 1776–1900* (New York: Hill and Wang, 1999); Frank Ninkovich, "Ideology, the Open Door, and Foreign Policy," *Diplomatic History* 6 (1982): 185–208.

implicitly – that is, unstated yet always to be found as justifications for action. In all cases, the technologies discussed in this book were the subject of ideological beliefs and claims about the proper control of information and communication networks.[9]

The second conceptual tool, *critique*, names the process through which ideological beliefs may be put into practice. My starting point here is Michel Foucault's insight that "critique only exists in relation to something other than itself" – that is, it is always a response to external conditions. Critique, Foucault continued, is "the art of not being governed quite so much … not to be governed thusly, like that, in this way."[10] Critique is therefore a strategic response that "must be an instrument for those who fight, resist, and no longer want what is. It must be used in processes of conflict, confrontation, and resistance attempts.… It is a challenge to the status quo."[11]

The philosopher Gerald Raunig, picking up on Foucault's notion of critique as a response to existing conditions, suggested that it might also be the foundation of a more productive act: "At the same time," he argued in 2008, "critique also means re-composition [and] invention."[12] In this view, critique is much more than a process of criticizing, belittling, or tearing down; it is also a process of creating, promoting, and building anew. Accordingly, the concept of critique in cultural theory can come to share common ground with Joseph Schumpeter's notion of "creative destruction" in economic theory: both concepts emphasize that creativity and innovation do not occur in a vacuum, but rather respond in an active and at times aggressive way to that which already exists.[13]

Throughout this book, I extend this line of inquiry to study acts of critique (and, in many cases, creative destruction) that were advanced by telephone and computer engineers. In some cases, these engineers offered *explicit* critiques – clear remarks on existing political, market, and technical issues – in private meetings, conference presentations, and written publications. In other cases, their critiques and challenge to the status quo were *implicit* in their creation of new artifacts, new software, and new institutions – collective acts of recomposition and invention that were not always accompanied by explicit

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[9] For an insightful discussion of various meanings of "control," see Gustav Sjoblom, "Control in the History of Computing: Making an Ambiguous Concept Useful," *IEEE Annals of the History of Computing* 33 (2011): 88–90.

[10] Michel Foucault, "What Is Critique?" in David Ingram, ed., *The Political* (Malden, MA: Blackwell, 1978), 192–193, 208.

[11] Michel Foucault quoted in Gerald Raunig, "What Is Critique? Suspension and Recomposition in Textual and Social Machines," *Transversal* (2008), http://eipcp.net/transversal/0808/raunig/en (accessed January 17, 2012). See also Terry Eagleton, *The Function of Criticism* (New York: Verso, 2006).

[12] Raunig, "What Is Critique?"

[13] Joseph A. Schumpeter, *Capitalism, Socialism, and Democracy* (New York: Harper & Row, 1976 [1942]).

claims of superiority. When we interpret engineering practice as acts of implicit and explicit critique, we will be in a better position to understand how new standards and new networks emerge as components of broader visions that respond to the past and present and that seek to redistribute power and control in the future. The "open systems" created in the late twentieth century, and the "open standards" described by the title of this book, thus constitute critiques and rejections of ideologies of centralized control.[14]

Making Open Systems

By the time engineers started referring to their computer and information networks as open systems in the late twentieth century, the concept of openness had become loaded with particular political, economic, technical, and cultural meanings. How did the term accumulate such symbolic weight? What did the language of openness mean to the people who deployed it, and what did it critique?

To answer these questions in the American context we need to begin by recalling the American colonies in the late eighteenth century, when American colonists split from Britain and created a new political system and a new information system at the same historical moment. The new political system rejected the British monarchy in favor of an American republic; the new information system rejected the British notion that kept knowledge, and therefore power, in the hands of the Crown and its allies. Both changes shared a basic ideological orientation: new liberal and local practices replaced the old restrictive and remote traditions.

At first, the information system in the American colonies – that is, the institutions, rules, and physical means of disseminating information – replicated European precedents set by absolutist rulers in England and France and the authorities in the Vatican who controlled the production and dissemination of printed materials through regimes of licensing, stamp taxes, state-backed guilds, and monopoly control of postal networks. In the American colonies, change came to this restrictive ancien régime as part of a broader colonial reaction against British rule. The major turning point came with the Stamp Act, passed by Parliament in February 1765 and scheduled to take effect at the beginning of November of the same year. For a majority of colonists, the amount of the tax did not threaten economic hardship; nevertheless, many reacted furiously to the notion that Parliament could tax them without their consent.[15] They summarized their principles in a slogan that every American schoolchild memorizes: No taxation without representation.[16]

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[14] Raunig, "What is Critique?" See also Helen Nissenbaum, "How Computer Systems Embody Values," *Computer* (March 2001): 118–120.

[15] Edmund S. Morgan, ed., *Prologue to Revolution: Sources and Documents on the Stamp Act Crisis, 1764–1766* (Chapel Hill: University of North Carolina Press, 1959), 45–49.

[16] Robert Darnton, "An Early Information Society: News and Media in Eighteenth-Century Paris," *American Historical Review* 105 (2000): 1–35; Starr, *Creation of the Media*, 28–39; Brown,

Some opposition to the Stamp Act cited a natural bond between unfettered communication and political liberty, such as a famous series of 1765 newspaper articles written by John Adams.[17] Adams warned his readers of the political dangers of the Stamp Act ("a design is formed to strip us in great measure of the means of knowledge," he wrote), but he also warned of the Act's *material* dangers. In keeping with British traditions but running against American expectations, the Act required a wide range of colonial documents – including commercial and legal forms such as ship inventories, court records, contracts, and wills; public documents such as newspapers and pamphlets; and recreational goods such as almanacs, calendars, and playing cards – to be printed on paper that was manufactured with a stamp impressed in it. Such stamped paper could be purchased only from designated agents who, in turn, received it from printers in London. Understood in material terms, the Act was an attempt to favor state-sponsored monopolies, establish a new supply-and-distribution hierarchy, and mandate new standard stationary upon a resistant network of lawyers, printers, merchants, citizens, consumers, and users.[18]

The Stamp Act, "as if designed to inflame the most articulate" (in Paul Starr's apt summary), ultimately inspired colonists such as Patrick Henry and Samuel Adams to create the first intercolonial networks of resistance, including the Sons of Liberty and Committees of Correspondence, against British authority.[19] After American independence was declared and defended, literate Americans shared the expectation that neither government officials nor religious leaders or social elites had the power or the right to dictate what could or could not be purchased and read.[20] To be a good citizen, an American needed to be literate and knowledgeable. "Print had come to be seen as indispensable to political life" as early as 1765, observed the literary historian Michael Warner, "and could appear to men such as [John] Adams to be the primary

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Knowledge is Power, 41 ("restrictive character of European information systems"); and Stephen Botein, "'Meer Mechanics' and an Open Press: the Business and Political Strategies of Colonial American Printers," *Perspectives in American History* 9 (1975): 127–225.

[17] Bernard Bailyn, *The Ideological Origins of the American Revolution* (Harvard University Press, 1967); Edmund S. Morgan and Helen Morgan, *The Stamp Act Crisis: Prologue to Revolution* (Chapel Hill: University of North Carolina Press, 1995/1953); Starr, *Creation of the Media*, 65–67; John Adams, "A Dissertation on the Canon and Feudal Law," Charles F. Adams, ed., *The Works of John Adams, III* (Boston: Little and Brown, 1851), 447–464.

[18] For a survey of surviving "America" stamps, see Adolph Koeppel, *The Stamps that Caused the American Revolution: The Stamps of the 1765 Stamp Act for America* (Manhasset, NY: Town of North Hempstead American Revolution Bicentennial Commission, 1976).

[19] Starr, Creation of the Media, 65.

[20] Of course, not all Americans shared the same literary tastes, nor did they have equal access to books, newspapers, and pamphlets. The information marketplace certainly was more dynamic in the northeast, but slaves, along with the rural and urban poor in the north and especially in the south, did not share in the information abundance of the early republican era. Brown, *Knowledge is Power*, 197–244 and 268–296.

agent of world emancipation."[21] But most printers were not concerned with world emancipation; they were a pragmatic group who were more interested in their personal economic circumstances. They wanted to sell more newspapers and books. As a result, the republican print ideology depended on – and was a construction of – a commercial vision of an open print marketplace. In historian Marcus McCorison's summary, the "traditional aim of the newspaperman was to profess political, economic, and social subservience to no faction and to keep his press freely open."[22] The historian Richard Brown notes that these commercial values of printers meshed well with American expectations of free speech and open communication: "Free speech was not always and everywhere honored, especially in the slave states, but free speech and open access to America's information system was the normal expectation."[23]

American politicians began to use the discourse of openness conspicuously at the turn of the twentieth century, in the context of American foreign policy in China. The "Open Door" policy took shape through a series of notes that U.S. Secretary of State John Hay sent to imperial administrations in Britain, France, Germany, Italy, Japan, and Russia. Hay was concerned that imperial competition over Chinese ports might disrupt opportunities for American commercial interests. To prevent China from being carved into imperial spheres of influence, Hay advanced an informal policy that would, in principle, respect Chinese territorial and administrative integrity.

Historians interpret the Open Door as an expression of the expansionist urges of the American economic system that was built on an implicit critique of European-style imperialism. It was, in one summary, an effort on the part of American diplomats and industrialists to make "the best use of mutual distrust inherent in the European principle." Open Door ideology called for a system of international relations that favored fair trade, peaceful cultural expansion, minimal government intrusion, and the avoidance of political and especially military entanglements. Although the new American principles ostensibly called for moralistic nonintervention in foreign affairs, historians such as William Appleman Williams have argued that the Open Door in practice marked the emergence of a new style of intervention where economic imperialism replaced the older practices of territorial colonialism, thus allowing Americans to "win the victories without the wars." Open Door ideology, in Williams's influential reading, became "the keystone of twentieth-century American diplomacy." By insisting on a "world open to American ideas and influence," Open Door ideology created the conditions where Americans could pursue "informal empire"

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[21] Michael Warner, *The Letters of the Republic: Publication and the Public Sphere in Eighteenth-Century America* (Boston: Harvard University Press, 1990), 32. See also Brown, *Knowledge is Power*, 287; and Brown, *The Strength of a People*, 49–118.

[22] Marcus A. McCorison, "Forward," Bernard Bailyn and John B. Hench, eds., *The Press & the American Revolution* (Boston: Northeastern University Press, 1981), 2.

[23] Brown, "Early American Origins of the Information Age," 52.

in the Pacific while proclaiming the high-minded and progressive principles of national self-determination and international peace.[24]

In the middle decades of the twentieth century, prominent philosophers, scientists, and theorists in the United States and Europe embraced "open" metaphors in their work. Unlike the Open Door policy's explicit confrontation with international diplomacy in the early twentieth century, the mid-century experts who wrote about open societies, open economies, and open systems retreated from geopolitical realities and instead applied the discourses of openness to their theoretical, structural, and systematic investigations.

For example, the philosophers Henri Bergson and Karl Popper posed stark dichotomies between social customs that they called "open" and "closed." Bergson drew a distinction in *The Two Sources of Morality and Religion* (1932) between "closed morality" and "open morality," where the former concept described an exclusionary and static society that promoted social cohesion and carried a deep preoccupation with strict internal obedience and war against all enemies. "Open morality," on the other hand, had a higher regard for creativity and progress; it was, according to Bergson, inclusive, universal, and peaceful. Popper's more famous 1945 book, *The Open Society and Its Enemies*, sketched an equally stark contrast. Popper argued that knowledge is provisional and fallible – not absolute – and therefore societies must accept new and diverse points of view. "Open societies" thus required moral foundations of humanitarianism, equality, and political freedom. One common thread between Bergson and Popper was their clear identification of openness with a wide array of progressive, peaceful, and inclusive values. Together they built a philosophical case that led to an inevitable (if understated) conclusion: open morality and open societies were superior alternatives to fascist and communist oppression.[25]

Experts in economics, sociology, and mathematics also adopted open metaphors in the 1930s and 1940s and, even more than the philosophers, took refuge from political and military conflict in the specialized language of their own disciplines. In 1939, the British Keynesian economist George Shackle published an article titled "The Multiplier in Closed and Open Systems," a commentary

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[24] Ninkovich, "Ideology, the Open Door, and Foreign Policy"; Yoneyuki Sugita, "The Rise of an American Principle in China: A Reinterpretation of the First Open Door Notes Toward China," in Richard Jensen, Jon Davidann and Yoneyuki Sugita, eds. *Trans-Pacific Relations: America, Europe, and Asia in the Twentieth Century* (Westport, Connecticut: Praeger Press, 2003), 3–20; William Appleman Williams, "Open Door Interpretation," in *Encyclopedia of American Foreign Policy: Volume 2*, Alexander Deconde, ed. (New York: Charles Scribner's Sons, 1978), 703–710; William Appleman Williams, *The Tragedy of American Diplomacy*, (New York: WW Norton & Company, 1972 [1959]), 45–57; Jerry Israel, *Progressivism and the Open Door: America and China, 1905–1921* (Pittsburgh: University of Pittsburgh Press, 1971); Andrew J. Bacevich, *American Empire: The Realities and Consequences of U.S. Diplomacy* (Cambridge: Harvard University Press, 2002).

[25] Henri Bergson, *The Two Sources of Morality and Religion* (New York: Doubleday Anchor, 1935 [1932]); Karl Popper, *The Open Society and its Enemies* (London: Routledge, 1945).

on the theoretical uncertainties inherent in export and import values in an "open economy."[26] The language of open systems also appeared in the work of the sociologist Talcott Parsons, who in 1943 described the "Kinship System of the Contemporary United States" as an "open, multilineal, conjugal system," one in which individuals choose their marriage partners rather than having marriages arranged on their behalf. In 1945, the term "open systems" appeared again in a different context – this time in the journal *Philosophy of Science*. Arturo Rosenblueth and Norbert Wiener published an article, "The Role of Models in Science," where they contrasted theoretical models that they called "closed box" and "open box." The distinction between these two types of models came from the number of fixed finite variables that each system had: fewer in closed boxes, many more in open boxes. "All scientific problems," they explained, "begin as closed-box problems, i.e., only a few of the significant variables are recognized. Scientific progress consists in a progressive opening of those boxes."[27]

Amid these provocative yet scattered ideas of the 1930s and 1940s, the Austrian biologist Ludwig von Bertalanffy began to build a general account of the properties of all open systems. In his 1950 article, "The Theory of Open Systems in Physics and Biology," von Bertalanffy drew on insights from biology, thermodynamics, and evolutionary theory to propose a basic definition: "A system is closed if no material enters or leaves it; it is open if there is import and export and, therefore, change of the components." Later that year, von Bertalanffy argued for the existence of a set of "*general system laws* which apply to any system of a certain type, irrespective of the particular properties of the system or elements involved." These laws formed the basis of his proposal for a "General System Theory," a direct critique of the "mechanistic world-view" that had "found its ideal in the Laplacean spirit." In place of this static worldview, von Bertalanffy proposed a "unification of science" around the "central problem" of "dynamic interaction" whose "general principles are to be defined by System Theory."[28]

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[26] G.L.S. Shackle, "The Multiplier in Closed and Open Systems," *Oxford Economic Papers* 2 (May 1939): 135–144. Shackle did not comment in his article on his choice of the term "open system," but in a later interview he recalled the many "famous" and "thrilling" visitors who he met as a graduate student in F.A. Hayek's seminar in the mid-1930s – including Karl Popper on his first lecture in England in 1936. Soon after publishing his article, Shackle joined Churchill's staff of economic advisors for the duration of World War II. "An Interview with G.L.S. Shackle," *The Austrian Economics Newsletter* (1983), available from http://mises.org/journals/aen/aen4_1_1. asp (accessed January 27, 2012).

[27] Talcott Parsons, "The Kinship System of the Contemporary United States," *American Anthropologist*, New Series, 45 (1943): 22–38; Arturo Rosenblueth and Norbert Wiener, "The Role of Models in Science," *Philosophy of Science* 12 (1945): 316–321.

[28] Ludwig von Bertalanffy, "The Theory of Open Systems in Physics and Biology," *Science* New Series 111 (1950): 23–29; Ludwig von Bertalanffy, "An Outline of General System Theory," *British Journal for the Philosophy of Science* 1 (1950): 139–164.