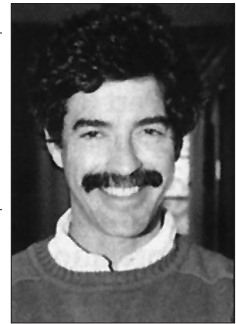

BOOK REVIEWS

*Stanley Wasserman,
Column Editor*



***Linked: The New Science of Networks*, by Albert-László Barabási, Cambridge, MA: Perseus Publishing, 2002. 280 pages.**

Reviewed by Rosanne Wasserman

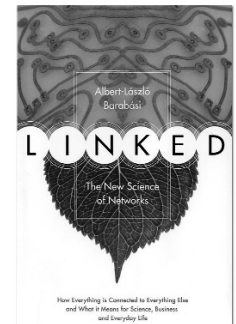
A physicist at the University of Notre Dame, Albert-László Barabási has a hit on his hands. There are already no fewer than seventeen downloadable book reviews listed on the excellent *Linked* website at the University of Notre Dame (www.nd.edu/~networks/linked) featuring questions and answers with Professor Barabási, sample pages, visuals, blurbs, and a quick way to order the book.

I like to read popular science books. Reading science isn't unusual for a poet; my mentor Ruth Stone (whose eighth collection of poems, *In the Next Galaxy*, just won the National Book Award for Poetry) has used her educated layman's knowledge as poetic material for nigh on sixty years. I myself have stolen words and phrases liberally and with glee from Jonathan Gleick's book *Chaos*, right up my alley. And there is surely an audience for books with titles like *Statistics for Poets* or the marvelous global investigations by brain surgeon Leonard Schlain: *Art and Physics* and *The Alphabet Versus the Goddess*. Some of this prechewed material, admittedly, becomes popular cliché right away: the "butterfly flutter in Tokyo—tornado in Toronto" sort of thing, for example. But some of it sails off tantalizingly above our heads, drawing us ever upwards, like Goethe's *Eternal Feminine*. Indeed, this effect may explain why soreheads among the science-writing population get irritated with the successful wooing of public interest by a talented elucidator:

Column Editor: Stanley Wasserman, Departments of Psychology and Statistics, University of Illinois, Beckman Institute, 603 East Daniel Street, Champaign, IL 61820-6266, USA; stamwass@uiuc.edu.

it looks like seduction, it looks unfair, and how come *we* can't get any?

True, an excited reassurance fills us when we see the vast and mysterious obvious nailed right down into a few neat equations, a dehydration of truth, encapsulated, reproducible, easy to swallow, and not too hard on the pocketbook. *Linked* isn't the double martini that *Chaos* was. We share his intense glee as he runs around with his antikaleidoscope, positioning its cylinder over cells and cocktail parties, freezing crystals and terrorist organizations: a toy or a tool that unscrambles complexity, that helps us read the world.



The book is well-written, beautifully paced, and entertaining, as so many have noticed. There are fifteen chapters expressed as links in the story Barabási has to tell. Each of the book chapters has about eight sections, nicely numbered, not too long. Each chapter deals with one aspect of networks, beginning with the preliminary researchers and formulations that led up to the particular work of Barabási and his team; moving to discussions of the nature of webs and networks, and their implications; ending with applications of these new insights on networks in various other fields of inquiry, remarkably diverse. As William Holstein wrote in the *New York Times*,

Barabási became fascinated with the structure of the Internet in 1998. He and his student researchers designed software robots that went out on the Net and mapped as many of its nodes, hubs and links as they could. He then began studying other networks and found that they had similar structures.

After a rousing introduction (which you can find online), the second chapter opens with a slice-of-biography look at the mathematician Leonhard Euler in 1783. Barabási moves on quickly to other mathematicians, to Paul Erdős and Alfréd Rényi; these two added to the ideas of network mathematics that Euler began. What they gave us was the concept of the random Bernoulli network, the old school of thought since 1959. It would look like a roadmap, says

Barabási, connecting city to city; the roads the links, the settlements the nodes, all quite random, like a Midwest Triple-A Triptik, holding off for the sake of his argument the old saying “All roads lead to you-know-where.” On page 69, he says at last, well, it’s NOT random, not in the Erdős—Rényi sense; there are hubs. He shows us the page at the back of the airlines magazine, where indeed all airways lead to Chicago’s O’Hare Airport. One feels a bit of discomfort here: “Shucks, I knew that!” But you didn’t know how to use that can-opener to perform brain surgery, did you? By the end of the book, you’ll see how it’s done. The name of this can-opener is the scale-free network, scale-free because there are smaller and larger nodes: they’re not all the same scale as one another.

Chapter three reiterates that even catchier phrase, “Six Degrees of Separation,” and reviews the “Six Degrees of Kevin Bacon” Hollywood movie game. All us Earthlings are nodes linked together by a mere six degrees, and that’s just a guess on the high side: if we only knew who knew whom, we’d probably be closer than six. Chapter four gives us the small-world concept and clustering: sociology, crickets, pheromones, and the Internet are major players here. Chapter five does the hubs and connectors. Six is the 80/20 rule, about robustness of networks: twenty percent of the nodes do all the work, and they’ll sustain the network should the other eighty percent go out on strike. In this chapter, Barabási introduces the concept of the power law, or power distribution as Nicholas Thompson calls it in his review in *The Washington Monthly*:

For years, researchers assumed that networks operated through what statisticians call “normal distributions,” with an average, or mean, and a bell curve around that average. Human height, for instance, follows a normal distribution, as most people are between five and six feet tall, with a few taller and a few shorter. But now we know that networks are often organized in what statisticians call “power distributions,” with most data points clustered together at a low level, with a few out on the extreme. If height followed a power distribution, most people would be very short, but numerous 100-foot-tall men and women would wander the streets, and at least one 8,000-foot-tall man would work somewhere as a window-washer.

The Ancient Egyptians must have intuited power laws in the social fabric much in the same way that Barabási envisions them for us: in terms of height. As so many of their tomb paintings demonstrate, most people are very very small; a few courtiers, generals, priests, and flunkies are ten times bigger; and then there’s the king himself, who is simply ENORMOUS. In other words, some people are unimportant; some have some power; and some are *gods*. But twenty percent of those serfs and middlemen still have to do the work so the system functions.

Chapter seven discusses preferential attachment, the force that creates the hubs. A most mysterious concept, preferential attachment describes but does not fully explain why some nodes turn into hubs. What force, for example, drove heiress Ruth Lilly to financially empower *Poetry Magazine*, for example, of all the nodes she might have chosen?

Chapter eight gets a bit closer to elucidating such mysteries, with the winner-take-all effect enjoyed by Microsoft: build a better mousetrap and the world beats a path to your node. Nine deals with cascading failures, one of the vulnerabilities of hub-centered networks; ten with viruses—network and human—and fads; eleven with the invention and growth of the Internet and its future; twelve with the labyrinthine task of mapping the worldwide web, which features a chart of sorts illustrating the Continents of a Directed Network.

Chapter thirteen exhibits the biological applications of network thinking, extending from the Internet to genes and cancer; as Holstein, the *New York Times* reviewer, phrases it, “The Internet in particular, he found, had taken on characteristics of a living ecosystem.” Chapter fourteen turns to economics, and again Holstein stresses this important popular angle. “Because of the multiplicity of connections, some things happen quickly. A good idea can win rapid acceptance. Professor Barabási uses the example of Hotmail’s explosion in popularity. Created on July 4, 1996, by Sabeer Bhatia and Jack Smith, it had one million users within a year. By the time Microsoft came knocking on the door to buy it a year later, it had 10 million.” Cisco and, of course, Microsoft are also discussed. The last chapter provides a wrap-up and points to the future.

Unanswered questions remain. It seems appropriate that, as a poet, I should follow the pattern of those reviewers who have up their sleeves their own agendas, new pretty places to set the lens: like James Brody, for instance, who in his *Human Nature Review* article human-nature.com/nibbs/02/linked.html, extends Barabási’s studies into details, well-documented, of biochemistry, biology, genetics, and even the thesarus. A sample:

Forty-three species were mapped for the average number of links between chemicals in their cells. Regardless of species size, but as Kauffman (1995) might have predicted, the number was approximately 3: a few molecules participate in the majority of reactions but most participate in only one or two. (According to *Nature Science Update*, July, 11, 2002, any two English words are connected on the average by only three degrees of separation!) Species are generally connected by 2 links on food chains. Milgram found that about 6 links separate any two Americans, scientists between 4 and 6, and 19 links will take you from any web page to any other (Barabási, 2002). (If anything, the web is overly complex in comparison with a cell or an ecosystem and may reflect the absence of selection pressure.)

There is lively discussion elsewhere, too; the Amazon.com “Write Your Own Review” sites feature what the simple folk have to say; some, as Flannery O’Connor might suggest, are not that simple. In particular, one New Yorker gripes (and rightfully so) that “networks have properties other than being scale-free—clustering, average path length, etc.,” and that “different types of networks tend to differ in these properties,” so “we are clearly missing a crucial piece of the picture.” Complexity, God bless it, remains to be mapped in someone’s future study.

Easiest to envision, I suppose, are social networks within the arts, the New York School's social network, for example, centering not on Kevin Bacon but on degrees of attachment to poets John Ashbery or Kenneth Koch, painters Larry Rivers or R. B. Kitaj, with the unknowable creative self, its own multiplex, at the center. Frank O'Hara (1959) tries, with tongue in cheek, to explain this new kind of poetic link, a one-poet movement called Personism:


But to give you a vague idea, one of its minimal aspects is to address itself to one person (other than the poet himself), thus evoking overtones of love without destroying love's life-giving vulgarity, and sustaining the poet's feelings towards the poem while preventing love from distracting him into feeling about the person. That's part of Personism. It was founded by me after lunch with LeRoi Jones on August 27, 1959, a day in which I was in love with someone (not Roi, by the way, a blond). I went back to work and wrote a poem for this person. While I was writing it I was realizing that if I wanted to I could use the telephone instead of writing the poem, and so Personism was born. It's a very exciting movement which will undoubtedly have lots of adherents. It puts the poem squarely between the poet and the person, Lucky Pierre style, and the poem is correspondingly gratified. The poem is at last between two persons instead of two pages. In all modesty, I confess that it may be the death of literature as we know it.

Today, lots of poets and poetry journals use e-mail and publish online. It's a lifesaver in these pennypinching times. If the poem's text is not on paper, between two pages, it's between two nodes now, two webusers, more like a synapse jumping from nerve to nerve. We know, too, though, that not all that jumps is received. The light from stars now inactive, messages sent from an other-world, attachments to negative nodes remain important, since many poets feel more strongly about texts than about live people. Some hear the voices of the dead; some are most strongly linked to the Other Side. What the nature of those links might be is the stuff of Edgar Cayce books, James Merrill's Ouija board, and wildly misspent public funding. Nor should we overlook preferential detachment, unconscious or willful denials of the claim that nothing human is alien. But you know who your own nodes are, don't you?—you see them in your dreams.

Those of us who remain firmly on the side of the snowflake, spokesfolk for infinite variety, will have such reservations, especially where they focus on the human: That butterfly's alighting on a temple bell—a famous image from a Zen haiku—could knock a major network hub out in Tokyo, make him burn his Palm PDA and move to a Buddhist retreat. The vanishing hub: the black hole. Take Emily Dickinson's "I'm nobody! Who are you?" vs. Walt Whitman's "I contain multitudes"—density of systems! Negative capability, as John Keats named the all-thumbedness that protects the poet from worldly competence, must have a function in a network, too, as

an antinode, an antipode, the opposite of linkedness: a stolen weekend in the Virgin Islands, a lost weekend under the volcano, that quantum particle vanishing and returning. The random, or one of its avatars—do we mean chaos? do we mean the irrational? whatever we don't understand?—continues to appear within the patterned. What is the nature of the individual link? What variances follow what laws there? Will we find connectors weak and strong, with charms and strange attractors?—if I may draw some sound/sense links from other fields of physics. And from Japanese poetry, have you heard of the form "linked-verse," or *renga*? Three or more poets compose alternate verses: node stanzas of the classic haiku form: 5, 7, 5 syllables; with link stanzas between the haiku of two seven-syllable verses. As in the Hebrew Torah tradition, a column of later commentary often accompanies the extremely compressed *renga* text. In Chaucer's time, the art of poetry was called numbers.

In the next decade's offering, Brain Neurology 101, will we learn that left and right hold all the network's nodes and the corpus callosum is all the links? As we age, as I age, some of those nodes seem to be getting to be what Barabási calls "OUT continents," one-way systems: the question goes in but it never comes out again. I hope for at least twenty-percent brain function when I reach eighty.

Linked! Linked! It's a hopeful concept, and I like the way it sounds. "No man is an island," though some websites are, and hundreds of millions of .mp3 songs are just a click away. Talk about preferential attachment? Talk about gravity fractals! A pebble has some magnetic pull; the planet a whole lot more. What IS this force that grows the link? And how many mysterious OUT-continent sites nest in their purple ribbons, in some cyberattic, about to change the world? Barabási starts his book with the apostle Paul and his spiritual network. If the node rejected by the builder will become the hub of the temple, we have to ask ourselves: when, how, and from where will such links appear? 

References

- Brody, J. (2002), "Linked: Barabasi Raifies Kauffman, Demotes the Social Gene," *Human Nature Review*, Vol. 2: 312–316, www.human-nature.com/nibbs/02/linked.html.
- Holstein, W. J. (2002), "Lessons From Networks, Online and Other," *New York Times*, June 23, www.nd.edu/~networks/linked/nytimes1.html.
- O'Hara, F. (1959), "Personism: A Manifesto," September 3, www.colby.edu/~isadoff/cap/OHara_Personism.doc.
- Thompson, N. (2002), "Net Gain: A Review of Albert-Laszlo Barabasi's *Linked*," *The Washington Monthly*, July/August, www.washingtonmonthly.com/features/2001/0207.thompson2.html.