

# The Nature of Economies

JANE JACOBS



VINTAGE CANADA

# *The Nature of Economies*

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*Systems of Survival*

*A Schoolteacher in Old Alaska*

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Jane Jacobs was born in Scranton, Pennsylvania, and since 1968 has lived in Toronto, where she has taken an active role in helping to shape the city. Her previous books include *The Death and Life of Great American Cities* (1961), *The Economy of Cities* (1968), *The Question of Separatism* (1980), *Cities and the Wealth of Nations* (1984), *Systems of Survival* (1993), and *Schoolteacher in Old Alaska* (1996).

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## *Foreword*

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Theories and other abstractions are powerful tools only in the limited sense that the Greek mythological giant Antaeus was powerful. When Antaeus was not in intimate contact with earth, his strength rapidly ebbed. The aim of the talkative characters in this book is to bring rarefied economic abstractions into contact with earthy realities, meaning universal natural processes of development, growth, and stability that govern economic life.

The theme running throughout this exposition—indeed, the basic premise on which the book is constructed—is that human beings exist wholly within nature as part of natural order in every respect. To accept this unity seems to be difficult for those ecologists who assume—as many do, in understandable anger and despair—that the human species is an interloper in the natural order of things. Neither is this unity easily accepted by economists, industrialists, politicians, and others who assume—as many do, taking understandable pride in human achievements—that reason, knowledge, and determination make it possible for human beings to circumvent and outdo the natural order. Readers unwilling or unable to breach a barrier that they imagine separates humankind and its works from the rest of nature will be unable to hear what this book is saying.

In describing natural processes and selecting examples to illustrate them, I have hewed information from the fields of biology, evolutionary theory, ecology, geology, meteorology, and other natural sciences as the information is currently understood and interpreted by practitioners in these sciences. When, on infrequent occasions, my characters introduce their own interpretations of natural science, they make it clear that these are their own speculations. On economics they are much more opinionated in their insistence that it comes down to earth, but again they state out-rightly when they are being iconoclastic, and why.

I have used imaginary characters and didactic dialogue primarily because this venerable literary form is suited to expounding inquiry and developing argument, but also because the form implicitly invites a reader to join the characters and enter the argument too. A book equipped to speak for itself, more so than any other artifact. But to be heard, a book needs a collaborator: a reader with a sufficiently open mind to take in what the book is saying and dispute or agree, but in any case think about it. Insofar as that process is enjoyable and interesting as well as possibly useful—as I hope it may be—so much the better.

JANE JACOBS

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## DAMN, ANOTHER ECOLOGIST

“Hortense and Ben have broken up,” said Armbruster, waving a fax at Kate as she slid into the booth, balancing her cup of coffee.

“I’m sorry but not surprised,” said Kate. “Remember how Ben used to gloat over industrial disasters? He thought everything industrial or technological was unnatural and that everything unnatural was bad.”

“He meant well,” Armbruster said. “We need Jeremiahs, but it must have been depressing for Hortense to live with one. It seems the breakup happened some time ago and she’s gotten over it. She’s interested in a new man. Mind if I finish this fax? I only got it as I was leaving the house.”

In late morning they were sitting in an almost-empty coffee shop on lower Fifth Avenue, not far from Armbruster’s Gramercy Square apartment. It was an unappealing restaurant in a stretch of New York rapidly going upscale. Armbruster liked it as his morning hangout because its well-deserved unpopularity guaranteed seats for acquaintances dropping by. He lived alone, and since his retirement from a small book publishing company, he missed his work and its daily give-and-take with colleagues.

“Damn, Hortense has found another ecologist,” Armbruster grumbled as he continued reading the fax.

“That’s not surprising, either,” said Kate. “She’s an environmental lawyer, so those are the people she talks to, consorts with. Those and other lawyers.”

“But listen to this: His name is Hiram Murray IV. The Fourth! What an affectation.”

“He’s not to blame if his family ran out of names.”

“You drop off the numbers when they die. I dropped off my Junior when my father died. Only kings and popes hang on to numbers.”

“Maybe the other three are still alive—you don’t know.”

“Let’s see,” Armbruster mused aloud. “Number two would be his grandfather, and number one—” His eyes widened, exaggerating his customary owl-like expression. “Good heaven! Hortense is fifty. You don’t suppose—”

“No, I don’t think Hortense is running around with a kid. Read on.”

“Well, well, she’s planning to come back from California,” Armbruster read on. “He has a house in Hoboken. What’s an ecologist doing in Hoboken? She says I’ll like him and she’s bringing him over a week from Thursday unless she hears otherwise, and so on.”

“May I come too?” Kate asked. “It’ll be wonderful to see Hortense again. And remember, Armbruster, I’m a fringe ecologist myself.”

When Kate was denied tenure a few years previously in the biology department of the Long Island university where she taught and did neurobiological research, she found a job on

prospering science newsweekly, partly on the strength of her editing experience on *Systems Survival* a dialogue she and Armbruster had put together from conversations and reports by a little group Armbruster had got up to explore the different moral systems appropriate to different kinds of workers—such as police, legislators, clergy, and others holding positions of public trust, on the one hand, and manufacturers, bankers, merchants, and others engaged in commercial pursuits, on the other. Hortense, who was Armbruster's niece, had been one of the group. During her first several months in her unfamiliar work on the weekly, Kate had frequently asked Armbruster for help and advice with her editing. After she no longer needed his guidance, she continued to drop in on him from time to time out of friendship.

A week from the following Thursday, at Armbruster's small apartment—crowded with books and signed photographs of authors on walls and tabletops—Hortense and Kate greeted each other affectionately and Hortense introduced Hiram. At tedious faculty meetings, Kate had learned to pass the time by imagining childhood versions of her colleagues' faces. Now in Hiram, she saw a well-brought-up, thin-faced, eager boy grown into a good tweed suit and a receding hairline, his eagerness still intact.

As Hortense sat down on the sofa, Hiram remained standing, distractedly patting his jacket pockets. Kate glanced around the room in puzzlement. "Did you lose something, or misplace it?" she asked him.

"No, why—oh." He dropped his hands and smiled sheepishly. "I quit smoking five weeks and four days ago, and I still keep hunting for a cigarette." Hortense, Armbruster, and Kate, reformed smokers all, smiled sympathetically and Hortense patted his hand as he sat down beside her.

Knowing that Armbruster would be itching to deal with Hiram's dynastic pretensions, as soon as they were settled with drinks Kate remarked offhandedly to Hiram, "That Four after your name is unusual. Not unheard-of, of course, but unusual."

Hiram made room between a book and a photograph on an end table and set down his drink. "My father's a splendid old man, but he insists on being Three, so I have to be Four. He's an economist and he would've liked me to be an economist, too, but after a try I dropped it for environmental studies. Most people I knew—this was thirty years ago—thought that it was like majoring in canoeing or bird-watching, but Pop took what I was doing seriously. I just mention this to show how minor his crotchet about the numbers is. 'Live and let live' runs both ways. But I did draw a line. My own son is named Joel."

"What do you do as an ecologist?" asked Armbruster. "Rally people around to save the woods and punish polluters?" Hortense and Kate exchanged glances, as if to acknowledge Armbruster's implicit, not very kindly, reference to Ben.

"No, although saving forests and reducing pollution are important. I'm a fund-raiser and a facilitator. Specifically, I give organizational advice and help find grants for people—scientists—most of whom are trying to develop products and production methods learned from nature. Biomimicry, that approach is called. There's a book about it by that name. I'll get you a copy if you're interested. Two copies," he added, turning to Kate.

"Oh, I have it. I reviewed it," said Kate. "It's a good book, Armbruster. Broadly speaking, the aims are to make better materials than we manufacture now, but to make them at lif-

friendly temperatures and without toxic ingredients, like the filaments spiders make or the shell material abalones construct, for instance. Ideally, by imitating the chemistry of nature we should be able to make materials and products by methods that are benign and, at the end of their lives as products, return them to earth or sea to degrade benignly.”

“So many other possibilities are being explored,” said Hortense. “Think of the energy, so much artificial fertilizer, and chemicals such as weed killers that could be saved if grain fields didn’t require annual plowing or planting—if wheat or rye could grow like perennial grasses on the prairies. All green plants capture sunlight, but it’s a puzzle and wonder how duckweed captures sunlight so effectively and uses it so efficiently. That’s worth learning from. You got the idea, Armbruster?”

“Interesting,” Armbruster replied, “but it sounds like just another way for us to exploit nature—trying to get out of technological messes with more technological messes.”

Kate suppressed a snicker at Armbruster’s mischievous adoption of Ben’s persona and glanced at Hortense to catch her reaction. Hortense, who usually remained cool and elegant under provocation, uncharacteristically bristled. “No! This isn’t exploiting nature! It’s learning from nature, with the object of undoing damage and getting along with nature more harmoniously. Biomimics are the last people deserving thoughtless dismissal, Armbruster. You have no idea how difficult these puzzles are, how hard and complicated it is to learn the way prairies manage to replenish themselves year after year. What’s gotten into you? You didn’t use to be so negative and glib. You sound like Ben!”

“Just curious. You’ve put me in my place. But if these endeavors are so difficult, they may not be practical.”

When neither Hortense nor Kate replied, Hiram spoke up again, rubbing his forehead thoughtfully. “Biomimicry is a form of economic development. So caring about biomimicry requires caring about economic development—hoping it continues vigorously. Otherwise, we can’t hope for better products and safer methods. How else can we get them? Thinking about development has made me realize how similar economies and ecosystems are. That’s to say, the principles at work in the two are identical. I don’t expect you to believe this just because I say so, but I’m convinced that universal natural principles limit what we can do economically and how we can do it. Trying to evade overriding principles of development is economically futile. But those principles are solid foundations for economies. My personal biomimicry project is to learn economics from nature.”

“Bravo!” said Armbruster, sensing a book in the making. His eyes shifted to the tape recorder on a shelf.

“Uh-uh, Armbruster,” said Hortense. “No symposium; no reports. Not again. Can’t we have a conversation without that recorder? Can’t we just talk? Can’t you forget about trying to produce a book? There are so many other interesting things you could do, now that you have time.” Kate caught Hortense’s eye and, wagging her eyebrows, signaled to Hortense to pip down.

“Producing a book never crossed my mind,” Armbruster lied. “But it did cross my mind that I’d like a tape. Economic development interests me, too. What harm?”

“I don’t mind if Kate and Hortense don’t,” said Hiram. He finished the last of his drink and

set down his glass, with a questioning smile directed first to Hortense, then to Kate.

Hortense shrugged and Kate grinned while Armbruster moved his machine to the coffee table, pushed the record button, nodded to Hiram, and said, “What did you mean about learning economics from nature? Economies are human, not natural. They’re artificial, with the possible exception of primitive foraging.”

“A common assumption, and one can see why,” said Hiram. “After all, only human beings employ smart, educated border collies to herd sheep. Only human beings build hospitals and operate on cleft palates, or wrap snacks in plastic, or issue credit cards and send monthly bills. We differ from other creatures in the ways we make our living, but different doesn’t necessarily mean artificial. We don’t call bees’ activities artificial because they manufacture honey, nor beavers’ because they log and build dams, nor seahorses’ because the males hatch and nurture the young. We don’t call sunflowers artificial because they’re so much taller than daisies. Our own manual dexterity and brains are created by nature. What we can do with those assets comes to us as naturally as the ability to spin webs and to sting netted prey comes to spiders.”

“Not so fast,” said Armbruster. “I didn’t mean we’re biologically artificial but that we create artificial things and impose them on the world of nature. We make artificial leather, artificial turf for stadiums, artificial teeth, artificial ice, and so on. How can you say human beings don’t have artificial economies?”

“Armbruster, that’s like accusing spiders of artificiality because they’re spinning something other than cotton, flax, silk, wool, or hemp fibers,” said Kate. “Please relax and let’s listen before we argue.”

“If we stop focusing on *things*,” said Hiram, “and shift attention to the processes that generate the things, distinctions between nature and economy blur. That’s not a new idea. Early ecologists were quick to see—”

“Who were the early ecologists?” asked Armbruster.

“Botanists who became interested in plant communities—groups of plant species whose interdependence seemed so similar to economic relationships that the naturalists coined a new word for natural communities of organisms and based it directly on the word *economy*. That was late in the nineteenth century.”

“Wait!” said Armbruster, darting to his unabridged dictionary. “Aha, *economy* is derived from two Greek roots—*oiko*, meaning ‘house,’ and *nomos*, meaning ‘management’: house management. *Ecology* comes from the same root for ‘house,’ plus the root *logos* for ‘logic’ or ‘knowledge.’ So *ecology* literally means ‘house knowledge.’ Now, that’s strange, isn’t it? *Biology*, meaning ‘life,’ and *nomos*, ‘management’—*bionomy*, ‘life management,’ would have been more to the point. Victorian scholars were well grounded in Greek. Odd that they embraced jargon as imprecise as *ecology*.”

“Not odd when you realize they thought of ecology as ‘the economy of nature,’ ” said Hiram, “a definition still in currency. The very sound of their new word tagged it as the twin of *economy*. That was their point, regardless of literal meaning. They were studying the economy of nature. I’m studying the nature of economy. Same affinity, glimpsed from a different opposite angle.

“Natural processes obviously aren’t founded on human behavior,” Hiram continued. “Instead, nature affords foundations for human life and sets its possibilities and limits. Economists seem not to have grasped this reality yet. But many people engaged in various economic activities do realize it’s important to learn from nature and apply the knowledge to what they do. For instance, modern metallurgists can observe the changes that take place in the lattices of metallic crystals owing to temperature variations and alloy combinations—information old smiths had no access to, because they didn’t have X-ray crystallography. Architects and engineers accept the reality of natural forces of tension and compression and use the help of tables of properties of construction materials. Wine makers, cheese makers, and bakers grasp and value their cooperative relationships with yeasts and bacteria; sanitation engineers, physicians, and organic farmers have learned to do the same and are still learning.”

“In sum,” he went on, “all kinds of people now understand that their success depends on working knowledgeably along with natural processes and principles, and respecting those processes and principles. That’s very different from supposing that success depends on lore handed down from supernatural sources or on blind trial and error—and diametrically different from supposing that human beings are exempt from nature’s dictates or that they are masters of nature.”

“To repeat, I’m convinced that economic life is ruled by processes and principles we didn’t invent and can’t transcend, whether we like that or not, and that the more we learn of these processes and the better we respect them, the better our economies will get along.”

“That sounds pretty pessimistic,” said Armbruster. “Here we are, already loaded up with government regulations. And now you want to compile still more lists of economic rules and regulations decreed by nature?”

“Limits are part of it,” replied Hiram. “Awareness of them can prevent futility. Alchemists did better after they gave up trying to turn base metals into gold and to discover a universal solvent and instead applied themselves to studying chemistry. But here’s what interests me most: Natural principles of chemistry, mechanics, and biology are not merely limits. They’re invitations to work along with them.”

“I think it’s the same with economics. Working along with natural principles of development, expansion, sustainability, and correction, people can create economies that are more reliably prosperous than those we have now and that are also more harmonious with the rest of nature.”

“I’m glad to hear you say ‘the rest of nature,’ ” said Kate. “If it’s actually true that natural processes rule human economic life—or could if we’d let them—it follows that we’re an integral part of the natural world instead of its mere disturbers and destroyers.”

“That’s not necessarily a reassuring thought,” said Hortense. “Plenty of other animal species have naturally gone extinct, along with their practices, whatever they were—you know that, Kate. Nothing is more unforgiving of error than nature. If we poison our own water and air with hormone-mimicking chemicals that we don’t understand, it isn’t reassuring to realize that nature’s solution for maladaptations is extinction.”

Armbruster cut short the potentially interesting point Hortense had raised. “Before we move on to anything else,” he said, “I’d like to mention a few subjects that I consider

economic fundamentals. You haven't said one word about money. But economics is first and foremost about money. What does nature say about money?"

"Nature says money is a feedback-carrying medium," Hiram replied. "Money is useful for economic self-regulation in the process we've come to call negative-feedback control. But the usefulness of money is far from enough to explain how economies work."

"What about the law of diminishing returns?" asked Armbruster. "First you cream off what's easiest and cheapest to exploit, then getting more is increasingly hard and expensive. That's certainly fundamental to economic life."

"The law of diminishing returns is truthful and harsh," said Hiram, "but it explains little about economic life in the absence of the converse law, which we might call the law of responsive substitution, meaning that people seek or contrive substitutes for resources that have become too expensive. Obvious examples have been domesticated animals in place of wild game; petroleum in place of whale oil and, later, coal; plastics in place of tortoiseshell and ivory. But that raises questions about development which demand some analysis of development in the rest of nature."

"What are you going to do with your project of economic biomimicry?" asked Armbruster.

"Write a book, I suppose," said Hiram. "Or put it on the Web. Or make practical use of it in advising clients. But that's premature. I've only partly formulated it. This isn't my work, just my hobby, a sideline. My main work is finding funds to keep other biomimics going—even though they're a frugal lot."

"I don't want to pry," said Armbruster, "but what do you live on? Commissions from grants you help to find?"

"No, I get paid for my time as a consultant. And I do some lecturing. Fortunately, I inherited my Hoboken house from my mother. It's enough room for my office and two apartments that I rent out, as well as my own apartment. I drifted into consulting after my father and I provided a little capital to a group in New Jersey working with novel and promising ways of treating sewage. I soon saw that development work of that sort needed more research and experimental capital than we could dream of affording, so I began hunting for more and turned out to be good at it. You could say I found a niche in the environment. I can't imagine doing anything more interesting, because of the amazing people and ideas I got involved with, but it doesn't leave me much uninterrupted time."

"Which reminds me how late it is," said Hortense, rising.

"Wait," said Armbruster. "All you've told us is why you think learning economics from nature isn't outlandish. You haven't told us what you've learned. Can't you go a bit further?"

"Better not tonight. But we can arrange a time for me to bring you that book I promised and to talk some more." As Kate, Hortense, and Hiram were putting on their coats, Armbruster jubilantly stuck a Post-it note on his refrigerator door, reminding himself to stock up on blank cassettes.

## THE NATURE OF DEVELOPMENT

“Start where you like. I’ve no idea what to ask you,” said Armbruster two weeks later as he switched on his recorder at the next session with Hiram, Hortense, and Kate.

“I’d like to start with development,” said Hiram. “Where do new things come from? Why doesn’t everything stay as it previously was? Let’s define development as significant qualitative change, usually building up incrementally. But even single instances of qualitative change can be significant—for instance, resistance to specific antibiotics developed by some strains of bacteria.”

“Oh, I thought you were going to talk about economic development,” said Armbruster, his enthusiasm fading into disappointment.

“I am, but first come fundamentals applying to all development.”

“Does that include inanimate development?” asked Kate.

“How can there be inanimate development?” Hortense protested.

“Think a minute,” said Kate. “Rivers develop deltas by depositing silt. Waves develop sandbars. Volcanic eruptions develop mountains. Weather systems develop fronts and storms.”

“Let Hiram proceed,” said Armbruster. “Otherwise we’ll never get to economic development.”

“Means of development vary enormously,” Hiram continued, “as Kate has just indicated. A rabbit embryo and a bean sprout don’t develop by exactly the same means, even though they’re both alive. Yet an animal, a plant, a delta, a legal code, or an improved shoe sole—they all depend on the same underlying process for development.”

“Don’t expect me to take that outrageous statement on faith,” said Armbruster. “You must mean it metaphorically.”

“No, I’m not dealing in metaphors. Nineteenth-century embryologists and evolutionists were the first to try seriously to understand the development of one form from another as a natural process. The gist of their definitions of development was this: *differentiation emerging from generality*. Only four words—but they describe development on every scale of time and size, whether animate or inanimate.

“To take an example on a huge scale, consider the solar system. According to astronomers and physicists, it seems once to have been a vast cloud of matter. That was a generality. Differentiations emerged: the sun, fellow planets and their moons, along with various smaller debris and leftover generalized matter.

“Now, the next important point: Once the earth emerged as a differentiation, it became a new generality from which further differentiations could emerge. From the crust, in due course, emerged the kinds of differentiations Kate mentioned. So here’s the second univers



principle of development: *Differentiations become generalities from which further differentiations emerge.* In other words, development is an open-ended process, which creates complexity and diversity, because multiplied generalities are sources of multiplied differentiations—some occurring simultaneously in parallel, others in successions. Thus a simple basic process, when repeated and repeated and repeated, produces staggering diversity.

“On a tiny scale—say, an embryonic human being—the generality is a microscopical small fertilized egg. At first it divides into repetitions of itself, forming a blob of multiplied generality. The first differentiations to emerge, depending on their locations in the blob, are layers of three distinctly differentiated kinds of cells, called ectoderm, mesoderm, and endoderm. These three differentiations are also three new generalities, from which more and more differentiations can emerge, both simultaneously and in successions, producing the diverse and complicated tissues and organs of the developing baby. In the infant reproductive organ, a preserve of undifferentiated eggs or sperm is set aside for producing the next generation’s differentiations.”

“But babies aren’t a new thing,” said Hortense. “They’re a multiplication of what already exists.”

“To be sure, in one sense,” Hiram replied. “But in another sense, each is a unique individual. In either sense, each new one emerges by the process I’ve sketched. Evolutionists of course, were concerned not just with individuals but with how the species itself emerged—and all other species, living and extinct. They worked out long progressions of lineages—this is, sequential generalities and differentiations. The diverging sequences are conventionally depicted as a tree or bush of life, with human beings on a topmost twig of the mammal branch on the tree.

“Sequences of more limited scope are conventionally depicted in linear, comic-strip fashion, such as the development of the horse from a smallish, fully-toed, nondescript quadruped to a magnificent hooved steed. Or, to take an even narrower example, the various kinds of mammalian feet were differentiated from unspecialized feet of early mammals which had five generalized toes with claws, apparently much like the unspecialized feet of modern rats.

“Differentiations that emerged from those ratlike feet included hooves of horses, wings of bats, flippers of whales, paws of cats, and our own hands, which happen to be closer to the unspecialized early mammal feet than those others. In our case, the significant digit development—not nearly as spectacular or specialized as hooves, flippers, or bat wings—was our opposable thumbs, which permit our superb manual dexterity.”

“All you’ve told us so far, if you’ll pardon me, is obvious to the point of banality,” said Armbruster. “How else could differentiations emerge except from prior generalities?”

“My point exactly,” said Hiram. “While this is obvious to you, it was not obvious to anybody until fairly recently. Aristotle, and other learned men long after him, thought the human embryo began as a minuscule infant that grew larger and stronger in the womb. And even today many people can’t credit evolution, preferring to believe that the world and its creatures were preformed from the start, as stated in Genesis.”

“Those evolutionary graphics,” said Kate. “They’re useful for identifying lineages, but

they're incomplete and misleading. A horse requires more than its own ancestors. A horse implies grass. Grass implies topsoil. Topsoil implies breakup of rocks, development of fungi, worms, beetles, compost-making bacteria, animal droppings—no end of other evolution and lineages besides that of the horse.”

“Yes, I was coming to that next,” said Hiram. “It’s the last of three fundamental development principles: *Development depends on co-developments*. I mean that development can’t usefully be thought of as a ‘line,’ or even as a collection of open-ended lines. It operates as a web of interdependent co-developments. No co-development web, no development.”

“Aren’t you and Kate talking about this process only when it gets pretty far along?” asked Armbruster. “When it’s already very complicated? There surely had to be development without co-development before things became so complicated and webby.”

“Co-developments may always have been necessary to the process of differentiation,” Hiram replied. “Consider that the earth is not in the solar system by itself.”

“Okay, the planets need the sun or they couldn’t hold to orbits. But how does something like a delta need co-development?” asked Armbruster.

“A delta needs both water and grit. Neither, by itself, can develop a delta and each by itself is a result of co-developments,” Hiram answered.

“As a practical matter, development doesn’t occur in isolation. Every animal cell, including each of our own cells, of course, carries within it descendants of bacteria called mitochondria which have their own lineage, different from that of the cell in which they live. Mitochondria have their own genetic material—they evolved separately—but now they and our cells are symbionts, mutually dependent, although originally they may have co-developed as predator and prey.

“Mitochondria power our cells—generate energy—by combining sugar and oxygen; to oversimplify, mitochondria feed the flame of animal life by burning sugar. Cells of green plants benefit from co-developed symbionts called chloroplasts, which capture sunlight and use it as energy to free carbon—the basic food of plants—from carbon dioxide.”

“The waste product of chloroplasts is oxygen, which animals require,” said Kate. “The waste product of mitochondria is carbon dioxide, which plants require. Neither plants nor animals would have a feasible atmosphere to draw on or live in without the other.”

“Of course, Armbruster, co-development webs have become increasingly intricate as development has proceeded,” said Hiram. “But we’ve every reason to believe that mutual and influential co-developments are as old as development. In their growing intricacy, they come to incorporate all degrees of cooperation—”

“Now you *are* drifting into metaphor,” said Armbruster. “Cooperation implies conscious intent. Can you properly speak of cooperation among plants or animals that don’t know they’re cooperating? When it’s just the way things are for them?”

“That’s a blurry line,” said Hortense. “An ecologist in Oregon, back home from Botswana, told me about the honey bird, a drab little thing notable for being able to digest beeswax. It can’t get at honey or wax by itself, because it would be stung to death. So it enlists human help by getting the attention of a hunter and leading him to a hive. The hunter overcomes the bees with a smudge fire, breaks open the hive, and shares the goodies with the bird.”

“I’ll grant that as cooperation,” said Armbruster, “because the hunter knows he cooperating.”

“Ah,” Hortense replied, “but the honey bird has one other species of helpers: small skunklike mammals. Naturalists suppose these were the bird’s traditional helpers. Same routine: The bird gets the attention of one of these creatures, leads it on, the animal backs up to the hive, sprays it with his powerful odor, breaks into the hive, and shares its goodies with the bird. If using a smoke smudge is cooperative behavior, why isn’t using a stink smudge?”

Before Armbruster could answer, Hiram admitted, “*Cooperation* was a poorly chosen word. Even among human neighbors, where cooperation indisputably exists, it can be inadvertent. My tenant told me he misses me when I’m out of town because he depends on hearing my morning alarm clock—inadvertent cooperation on my part. The world’s full of it. From now on, I’ll just speak of interdependence, leaving aside whether it’s intended or not.”

“All this co-development, cooperation, symbiosis, interdependence,” grumbled Armbruster. “The three of you make nature sound like a barn raising, everybody pitching in together. Where’s the fierce competition? Where’s the nature red in tooth and claw? Where’s survival of the fittest and devil take the hindmost?”

“Oh, competition’s there, and so are winners and losers,” said Hiram. “Losers die and winners eat. The honey bird, skunklike mammal and hunter in Hortense’s example are predators and the hive is prey. But that’s not the whole cast of characters. The bees and the honey wouldn’t exist without flowers, but the flowers wouldn’t exist without bees; and so on. Put it this way: Competitions for feeding and breeding take place in an arena. The arena is the habitat. The fittest panther in the jungle is a goner if its habitat goes. And what is a habitat? It’s an intricate, complicated web of interdependencies.”

“An economy consists of interdependent relationships, competing and yet also knitting together co-developments,” said Armbruster. “I agree with all that. Haven’t you prepared sufficiently to discuss economic development?”

“Yes,” Hiram answered, “but first I’ll remind you of the universal principles. Development is differentiation emerging from generality. A given differentiation is a new generality, from which further differentiations can potentially emerge. Thus the process is open-ended and produces increasing diversity and increasingly various, numerous, and intricate development relationships. All this is the consequence of one simple sort of event repeated, repeated, and repeated.”

“You’ve just identified a fractal,” said Kate.

“I keep coming across references to fractals,” said Hortense, “but what are they? And why should we care about them?”

“They’re complicated-looking patterns that are actually made up of the same motif repeated on different scales,” said Kate. “For instance, a muscle is a twisted bundle of fibers. Dissect out any one of those fiber bundles, and you find that it, too, is a twisted bundle of fibers. And so on. When you get down to the irreducibly smallest fiber, which you need an electron microscope to see, you find that it’s a twisted strand of molecules. That’s a real-life fractal. Mathematicians make computer-generated fractals, fascinating in their complexity and seeming variety, yet each fractal is made of repetitions.”

“We should care about fractals,” said Hiram, “because lots of things that seem impossible to comprehend become more understandable if we identify the basic pattern and watch what it produces through repetition. It’s a way of dealing with some complexities that otherwise are impenetrable—the way development as we’ve described it was impenetrable to Aristotle.”

“Of course, development still embodies mystery. Why should there be a force driving the universe toward intricacy and away from simplicity? But if the *why* of development is impenetrable, at least the *how* of development is discernible, and this has practical value, not least for economic development—”

“At last!” said Armbruster. “Wait till I change the cassette.”

“Economic development displays the same pattern as any other development,” Hiram resumed after their drinks were refreshed and Hortense, rummaging in the kitchen, had produced a tray of crackers and cheese. “This is most obvious when the differentiations happen to be new varieties of animals or plants.”

“Oh, please, let’s not get diverted back to nature,” said Armbruster.

“We’re in economic life now,” said Hiram, “specifically, agriculture and animal husbandry. Human beings have deliberately developed hundreds of new varieties—although not new species—of dogs, pigs, goats, and other animals, along with thousands of new varieties—also some new species—of edible and ornamental plants. They’ve done this by fostering desirable differentiations and selecting those worth further fostering. Have you ever tasted a wild orange? Awful, though beautiful. One of my clients has been developing cotton with color differences. No dye required.

“Our remote ancestors started developing tools and weapons with nothing that was of their own making. They began with found generalities—already provided by development in the rest of nature: sticks, stones, bones, fire. They differentiated those found generalities into hammers, spears, scrapers, pokers, and torches, and, as one development led to another, into bows, arrowheads, nets, rafts, pigments, trumpets, cloaks, bags, and so on. The more differentiations, the more generalities; and the more generalities, the more bases for further developments, and so on.

“Because that’s the universal development process, economic developments don’t come out of thin air. They have lineages and pedigrees, the same as other forms of natural development. Consider the wheel family, for instance. We can’t be sure of the ancestral generality from which the first wheel emerged, because that happened so far back in prehistory—”

“We can make a pretty good guess,” Kate interrupted. “The oldest known cartwheels were made of wood, and solid instead of spoked, so it’s reasonable to suppose the wheel’s ancestor was an ordinary log used as a roller beneath loads. The differentiation would have been a cross-section of a log penetrated by a central axle.”

“Maybe,” said Hortense, “but I think a toy is more plausible. I visualize small solid circles—say, slices of ginger-root or squash—that mothers twirled on sticks to amuse themselves and the children. It’s easier to slice a fruit or vegetable than a log. Kids who played with twirlers punched onto sticks might grow up to invent wheels.”

“In that case, the generality would have been a flimsy little thing,” said Hiram. “The

significant differentiation would have been a bigger copy in sturdier material. Could be. Lots of developments have begun as ornaments or amusements. The first railroad was a London amusement ride, developed specifically for that purpose.

“Let’s pretend we have an evolutionary tree of the wheel. Its root would be a rolling object of some kind, wood or other vegetable, yielding the differentiation of a solid wooden wheel. Branching off from it would be a lighter, stronger, and spoked wheel. In its turn, that would be a new generality, the progenitor of chariot wheels, spinning wheels, locomotive, car, truck, and airplane wheels, steering wheels, and the light, strong, tangentially spoked bicycle wheel.

“A major side-branch from the spoked wheel would bristle with the great family of rimless spoked wheels: water mill-wheels, windmills, fans, paddle wheels, propellers, food blenders.

“Returning our attention to the old solid wheel, we see that it branched into other unspoked wheels: the potter’s wheel, the windlass, toothed gear-wheels, circular saws, rotating dials, phonograph turntables, movie projectors.

“As for the humble log roller that may or may not have been at the root of the wheel tree from it emerged such differentiations as cane pressers, rolling pins, pulleys, rollers for forming sheet steel, rotary printing presses, hair curlers.”

“That’s very cute,” said Kate, “with all its surprising anachronisms. But it’s misleading. I grant that vehicular wheels preceded spinning wheels, but taken alone, vehicular wheels explain little about spinning wheels. Spinning implies fibers for making yarn and looms for using the yarn. Furthermore, your wheel lineages would make it seem that wainwrights developed gear wheels when it’s much more likely that windmill carpenters did, or even makers of clockwork toys. And how could bicycle wheels have been made without wires and screws, and where are the trees of wire and screw lineages—”

“You’re too quick for me, Kate,” said Hiram. “Yes, the wheel tree is misleading for the same reason as biological family trees: Its imaginary diagram is based on linear thinking about development instead of web thinking. Development without co-development webs is impossible for an economy as it is for biological development.”

“The Icarus myth says it,” said Armbruster. “The feathered wings his father made him wear were secured with wax, which melted when Icarus soared too near the sun. But feathers and wax are absurd generalities for differentiating human flight equipment. You’ve got me talking like you, Hiram.”

“That’s not what the myth meant to the Greeks,” said Hortense. “After all, Icarus did fly and Daedalus, his father, not only flew but landed safely. The Greeks weren’t expounding technology. You’ve given the myth a hindsight gloss, Armbruster.”

“The wreck of the *Titanic* makes essentially the same point Armbruster was making,” said Kate. “At the time the ship was built and when it embarked on its maiden voyage in 1912, metallurgy hadn’t advanced as much as engineering. Engineers had been able to design the largest man-made movable object, but the steel available to them couldn’t withstand the stress of the vessel’s size and it cracked under low impact with the iceberg. It was the best steel of its time.”

“Icarus makes me shudder,” said Hiram. “I’m nagged by thoughts of inventors ahead of

their times. Sure, abalones demonstrate that it's practical to make first-rate ceramics at life-friendly temperatures, but that may be like ancient Greeks musing that birds prove flight practical."

"Co-developments contrived for other purposes have to be in place, eh?" said Armbruster. "A question for you, Hiram. Do old economic generalities eventually become obsolete consequence of later development?"

"Possibly the very oldest economic generality is the practice of sharing," replied Hiram. "By that I don't mean random or inadvertent sharing but calculated, intended sharing as an institutionalized social practice. Along with us, our closest primate cousins, the chimpanzees and bonobos, go in for deliberate, socially formalized sharing. This suggests that the practice may go back to an ancestor common to the three of us, back to prehuman times. As far as economic life is concerned, the major differentiation that emerged from sharing was the practice of trading. A fossil form of English neatly records the developmental relationship. Old English had a verb meaning 'to give.' It also had a verb phrase meaning 'to trade,' which meant, literally, 'to give with worth'—that is, give for a price. Our word *sell* comes from a truncated portion of that phrase for trading, the part literally meaning 'give.'

"Time and again, human groups must have differentiated trading from both sharing and seizing. As a generality in its own right, trading has been a prolific source of further economic differentiations in transportation, communication, finance, markets, storage—"

"Also in development of legal codes involving contracts, ownership, and liabilities," said Hortense, "and social codes involving long-distance cooperation and relationships with strangers."

"Old as it is, sharing is still a potent generality," Hiram continued. "Economic developments still emerge from it. According to a report I ran across in 1996, a thriving cluster of commercial enterprises in Toronto ships old jeans to Cuba, coats to Russia, and ripped cloth to India to be recycled into thread. What's left goes to Montreal, the report said, to be recycled into upholstery for automobile seats. This recycled clothing is given by people who are through with it. Sometimes they give it directly to the old-clothes sorters and shippers, and sometimes to charities, which sell it to the sorters. What's new about these commercial enterprises is the convenient service they worked out for donors and the labor-saving arrangements they worked out for themselves. They use phone calls or printed fliers to inform householders of the days when they can leave their donations in front of their dwellings. These arrangements have now been copied by charities that collect clothes."

"Notice that even those simple improvements use co-developments such as telephone, printing, and transportation," said Kate.

"Yes, and retail stores are drawn in," said Hiram. "Local secondhand stores, some of them run by charities and some not, get first pick of the donations. The old-clothes sorters who organized this efficient version of the ancient generality of sharing glimpsed possibilities for themselves in an economic niche that hadn't yet been adequately filled."

"Here's another instance of a potent old generality, although not nearly as old as sharing or trading," said Kate. "But it's so unexpected. Yesterday I edited a little item for our coming issue about a superior new type of computer chip. Its inventors—among other c

developments they used—adapted a technique for employing very fine copper wire developed by Spanish jewelers in fifteenth-century Toledo. It got me thinking about obsolete generalities—how even the most obscure and frivolous are potentially economically fertile provided that somebody who needs them can find them. Kinds of work are an economic equivalent of ecosystems' gene pools. So it would make sense to keep on the lookout for endangered species of work.”

“Such as making buggy whips?” asked Hortense.

“Whips aren't an endangered species, and knowledge of how they're made is under no threat of extinction. Buggy whips are a tiresome cliché for obsolescence. However, manual typewriters are rapidly going extinct, and I doubt that mechanics are still learning to repair them, let alone make them.”

“Anthropologists often record endangered techniques used by the people they study who live in remote places,” said Hortense. “Then there are official patent-office records. And look how museum curators preserve specimens and sometimes information on ancient technologies for producing textiles, ceramics, glass, jewelry, and musical instruments. It seems to me we're pretty well provided with preservers of economic gene pools. But keeping track, as you suggest, Kate, is always bound to be important. A friend of mine who collects rugs tells me that some Turkish villagers are making beautiful Oriental rugs again, as fine as the finest antiques, thanks to reclaimed knowledge that was almost lost after aniline dyes replaced vegetable dyes around 1900. Besides making subtler and mellower color, vegetable dyes preserve the wool better. What's more, villagers who became idle dependents when harsh chemical dyes were being bought from outside now have work finding and preparing local plants. This affects the weavers' morale—I suppose they were resentful of people who didn't contribute while they themselves were hard at work—and the improved morale clearly affects the quality of the weaving, my knowledgeable friend claims.”

“But, obviously, the skills of vegetable dyeing hadn't been lost from the gene pool of work,” said Kate.

“Almost,” said Hortense. “Saved barely in time. A few great-grandmothers still had the knowledge. Some information was hunted down in journals and diaries kept by nineteenth-century travelers.”

“Notice the emphasis you've put on the old and beautiful,” said Kate. “That's all to the good, but what about humdrum work and products going extinct right now? Some of them are not all that old, either. Armbruster, this record you're making right now could possibly soon be lost irretrievably. Fifty reels of taped interviews made forty years ago became important to a Canadian investigative commission. Although the Viennese technology employed in making and playing back the tapes had once enjoyed an international success, an international search turned up not one machine to play back those tapes. Control of the speed with which the reels wound and unwound as their diameter changed—that was the problem. Recovering the content of the tapes was as daunting and delicate as restoring artifacts from ancient sites in caves and bogs. Computers have developed so rapidly that few are left which can decode information recorded only twelve years ago. The 'Knowledge Age' is going to become the Lost-Knowledge Age unless preserving specimens of work is taken as seriously as we've begun taking preservation of specimen varieties of apples and beans. Another thing

said Kate as an afterthought. “Knowledge of how to choose good transit routes seems to be going extinct, too, judging from cities that construct expensive transportation lines along ridiculous routes, then wonder why they’re underused.”

“That’s because people who knew where—and why—to run a subway or streetcar are all dead or long retired,” said Armbruster. “Traffic engineers try inappropriately to use what they’ve learned about truck and passenger-car routes. A different problem. But we’re digressing. Hiram, I accept your point that our economies imitate the way nature develops. Let’s move on.”

Hiram frowned and looked dismayed. “I’m afraid I haven’t been clear,” he said. “Economic development isn’t a matter of imitating nature. Rather, economic development is a matter of using the same universal principles that the rest of nature uses. The alternative isn’t to develop some other way; some other way doesn’t exist.

“Thousands of years before anyone had a glimmer of evolutionary or biological development processes, people were fostering differentiated strains of grains. Thousands of years before anybody was aware of symbionts such as mitochondria or chloroplasts, people were combining materials and devices that had radically different economic lineages. Even today, when educated people are aware of symbionts in the rest of nature, inventors who combine silicon chips with typewriter keyboards—or any other devices and materials with different economic lineages—aren’t imitating animal cells and mitochondria. Rather, they’re using universal principles of development and co-development for the good reason that no others are available. Economic development is a version of natural development.”

“This is an intellectually interesting way to look at economic life,” said Armbruster. “But what you’ve just said implies that it’s academic information. People don’t need to recognize the universal processes and principles to engage in using them. So is there any practical value or advantage in knowing that economic development is differentiations emerging from generalities?”

“Yes,” replied Hiram. “It tells us that development isn’t a collection of things but rather a process that yields things. Not knowing this, governments, their development and aid agencies, the World Bank, and much of the public put faith in a fallacious ‘Thing Theory’ of development. The Thing Theory supposes that development is the result of possessing things, such as factories, dams, schools, tractors, whatever—often bunches of things subsumed under the category of infrastructure.

“However, if the development process is lacking in a town or other settlement, things, either given or sold to it are merely products of the process somewhere else. They don’t mysteriously carry the process along with them. To suppose that things, per se, are sufficient to produce development creates false expectations and futilities. Worse, it evades measures that might actually foster development.”

“Such as?” asked Armbruster.

“Think about how the process works and therefore what it requires,” said Hiram.

“Well, it requires economically creative people.”

“Yes, and we human beings come by creativity naturally. Some people have more of it than others, whether by nature or nurture or both. Time and time again, it pops up in the mo-



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