The Nature of Economies

JANE JACOBS

VINTAGE CANADA

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The Nature of Economies

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

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For Burgin, Ned, and Jim

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

The theme running throughout this exposition—indeed, the basic premise on which th book is constructed—is that human beings exist wholly within nature as part of natural ord 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 the natural order of things. Neither is this unity easily accepted by economists, industrialist politicians, and others who assume—as many do, taking understandable pride in huma achievements—that reason, knowledge, and determination make it possible for human bein to circumvent and outdo the natural order. Readers unwilling or unable to breach a barri that they imagine separates humankind and its works from the rest of nature will be unab 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, meteorolog and other natural sciences as the information is currently understood and interpreted b practitioners in these sciences. When, on infrequent occasions, my characters introduce the own interpretations of natural science, they make it clear that these are their ow speculations. On economics they are much more opinionated in their insistence that it com 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 venerab literary form is suited to expounding inquiry and developing argument, but also because th 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 collaborator: a reader with a sufficiently open mind to take in what the book is saying ar dispute or agree, but in any case think about it. Insofar as that process is enjoyab interesting as well as possibly useful—as I hope it may be—so much the better.

JANE JACOBS

Toronto July 199

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Chapter 1

DAMN, ANOTHER ECOLOGIST

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

"I'm sorry but not surprised," said Kate. "Remember how Ben used to gloat over industri disasters? He thought everything industrial or technological was unnatural and th everything unnatural was bad."

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

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

"Damn, Hortense has found another ecologist," Armbruster grumbled as he continue reading the fax.

"That's not surprising, either," said Kate. "She's an environmental lawyer, so those are th 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 die 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 numb one—" His eyes widened, exaggerating his customary owlish 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 house in Hoboken. What's an ecologist doing in Hoboken? She says I'll like him and she 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 remembe Armbruster, I'm a fringe ecologist myself."

When Kate was denied tenure a few years previously in the biology department of the Lon 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 little group Armbruster had got up to explore the different moral systems appropriate t different kinds of workers—such as police, legislators, clergy, and others holding positions o public trust, on the one hand, and manufacturers, bankers, merchants, and others commercial pursuits, on the other. Hortense, who was Armbruster's niece, had been one the group. During her first several months in her unfamiliar work on the weekly, Kate ha frequently asked Armbruster for help and advice with her editing. After she no longer neede 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 wi books and signed photographs of authors on walls and tabletops—Hortense and Kate greete each other affectionately and Hortense introduced Hiram. At tedious faculty meetings, Ka had learned to pass the time by imagining childhood versions of her colleagues' faces. Nov in Hiram, she saw a well-brought-up, thin-faced, eager boy grown into a good tweed suit an a receding hairline, his eagerness still intact.

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

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

Knowing that Armbruster would be itching to deal with Hiram's dynastic pretensions, a soon as they were settled with drinks Kate remarked offhandedly to Hiram, "That Four aft 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 h drink. "My father's a splendid old man, but he insists on being Three, so I have to be Fou He's an economist and he would've liked me to be an economist, too, but after a try 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 wa doing seriously. I just mention this to show how minor his crotchet about the numbers i '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 th woods and punish polluters?" Hortense and Kate exchanged glances, as if to acknowledg Armbruster's implicit, not very kindly, reference to Ben.

"No, although saving forests and reducing pollution are important. I'm a fund-raiser an facilitator. Specifically, I give organizational advice and help find grants for people- scientists—most of whom are trying to develop products and production methods learne from nature. Biomimicry, that approach is called. There's a book about it by that name. I 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 speakin 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 th shell material abalones construct, for instance. Ideally, by imitating the chemistry of natur we should be able to make materials and products by methods that are benign and, at the en 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, soi artificial fertilizer, and chemicals such as weed killers that could be saved if grain fields didn require annual plowing or planting—if wheat or rye could grow like perennial grasses i prairies. All green plants capture sunlight, but it's a puzzle and wonder how duckwee captures sunlight so effectively and uses it so efficiently. That's worth learning from. You ge the idea, Armbruster?"

"Interesting," Armbruster replied, "but it sounds like just another way for us to explo 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 an glanced at Hortense to catch her reaction. Hortense, who usually remained cool and elega under provocation, uncharacteristically bristled. "No! This isn't exploiting nature! It's learnin from nature, with the object of undoing damage and getting along with nature mor harmoniously. Biomimics are the last people deserving thoughtless dismissal, Armbruste You have no idea how difficult these puzzles are, how hard and complicated it is to learn th way prairies manage to replenish themselves year after year. What's gotten into you? Yo 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 ma not be practical."

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

"Bravo!" said Armbruster, sensing a book in the making. His eyes shifted to the tap recorder on a shelf.

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

"Producing a book never crossed my mind," Armbruster lied. "But it did cross my min 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 an

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 coffe table, pushed the record button, nodded to Hiram, and said, “What did you mean abo learning economics from nature? Economies are human, not natural. They’re artificial, wi the possible exception of primitive foraging.”

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

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

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

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

“Who were the early ecologists?” asked Armbruster.

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

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

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

“Natural processes obviously aren’t founded on human behavior,” Hiram continue
“Instead, nature affords foundations for human life and sets its possibilities and limit
Economists seem not to have grasped this reality yet. But many people engaged in variou
economic activities do realize it’s important to learn from nature and apply the knowledge
what they do. For instance, modern metallurgists can observe the changes that take place
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 crystallograph
Architects and engineers accept the reality of natural forces of tension and compression an
the help of tables of properties of construction materials. Wine makers, cheese makers, an
bakers grasp and value their cooperative relationships with yeasts and bacteria; sanitar
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 o
working knowledgeably along with natural processes and principles, and respecting thos
processes and principles. That’s very different from supposing that success depends on lor
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 the
are masters of nature.

“To repeat, I’m convinced that economic life is ruled by processes and principles we didn
invent and can’t transcend, whether we like that or not, and that the more we learn of thes
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 wit
government regulations. And now you want to compile still more lists of economic rules an
regulations decreed by nature?”

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

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

“I’m glad to hear you say ‘the rest of nature,’ ” said Kate. “If it’s actually true that natur
processes rule human economic life—or could if we’d let them—it follows that we’re a
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 anim
species have naturally gone extinct, along with their practices, whatever they were—yo
know that, Kate. Nothing is more unforgiving of error than nature. If we poison our ow
water and air with hormone-mimicking chemicals that we don’t understand, it isn’t reassurin
to realize that nature’s solution for maladaptations is extinction.”

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

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

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

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

"The law of diminishing returns is truthful and harsh," said Hiram, "but it explains litt about economic life in the absence of the converse law, which we might call the law responsive substitution, meaning that people seek or contrive substitutes for resources th have become too expensive. Obvious examples have been domesticated animals in place wild game; petroleum in place of whale oil and, later, coal; plastics in place of tortoiseshe and ivory. But that raises questions about development which demand some analysis 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 i advising clients. But that's premature. I've only partly formulated it. This isn't my work, ju my hobby, a sideline. My main work is finding funds to keep other biomimics going—eve though they're a frugal lot."

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

"No, I get paid for my time as a consultant. And I do some lecturing. Fortunately, inherited my Hoboken house from my mother. It's enough room for my office and tw apartments that I rent out, as well as my own apartment. I drifted into consulting after m father and I provided a little capital to a group in New Jersey working with novel an promising ways of treating sewage. I soon saw that development work of that sort neede more research and experimental capital than we could dream of affording, so I began huntin for more and turned out to be good at it. You could say I found a niche in the environment. can't imagine doing anything more interesting, because of the amazing people and ideas I g 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 fro 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 promise and to talk some more." As Kate, Hortense, and Hiram were putting on their coat Armbruster jubilantly stuck a Post-it note on his refrigerator door, reminding himself to stoc up on blank cassettes.

Chapter 2

THE NATURE OF DEVELOPMENT

"Start where you like. I've no idea what to ask you," said Armbruster two weeks later as h 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? Wh doesn't everything stay as it previously was? Let's define development as significa qualitative change, usually building up incrementally. But even single instances of qualitativ change can be significant—for instance, resistance to specific antibiotics developed by som strains of bacteria."

"Oh, I thought you were going to talk about economic development," said Armbruster, h 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 develo sandbars. Volcanic eruptions develop mountains. Weather systems develop fronts and storm —"

"Let Hiram proceed," said Armbruster. "Otherwise we'll never get to econom development."

"Means of development vary enormously," Hiram continued, "as Kate has just indicated. rabbit embryo and a bean sprout don't develop by exactly the same means, even thoug 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 mu mean it metaphorically."

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

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

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

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

"On a tiny scale—say, an embryonic human being—the generality is a microscopicall small fertilized egg. At first it divides into repetitions of itself, forming a blob of multiplie generality. The first differentiations to emerge, depending on their locations in the blob, ar layers of three distinctly differentiated kinds of cells, called ectoderm, mesoderm, an endoderm. These three differentiations are also three new generalities, from which more an more differentiations can emerge, both simultaneously and in successions, producing th 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 producin the next generation's differentiations."

"But babies aren't a new thing," said Hortense. "They're a multiplication of what alread exists."

"To be sure, in one sense," Hiram replied. "But in another sense, each is a uniqu individual. In either sense, each new one emerges by the process I've sketched. Evolutionist 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—th is, sequential generalities and differentiations. The diverging sequences are conventionall depicted as a tree or bush of life, with human beings on a topmost twig of the mamm branch on the tree.

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

"Differentiations that emerged from those ratlike feet included hooves of horses, wings o bats, flippers of whales, paws of cats, and our own hands, which happen to be closer to th 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—wa 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," sa 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 t anybody until fairly recently. Aristotle, and other learned men long after him, thought human embryo began as a minuscule infant that grew larger and stronger in the womb. An even today many people can't credit evolution, preferring to believe that the world and i creatures were preformed from the start, as stated in Genesis."

"Those evolutionary graphics," said Kate. "They're useful for identifying lineages, bu

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

"Yes, I was coming to that next," said Hiram. "It's the last of three fundament development principles: *Development depends on co-developments*. I mean that developme can't usefully be thought of as a 'line,' or even as a collection of open-ended lines. It operate 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?" aske Armbruster. "When it's already very complicated? There surely had to be developme 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 somethin 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 itse is a result of co-developments," Hiram answered.

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

"Mitochondria power our cells—generate energy—by combining sugar and oxygen; t oversimplify, mitochondria feed the flame of animal life by burning sugar. Cells of gree plants benefit from co-developed symbionts called chloroplasts, which capture sunlight an 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. "Th waste product of mitochondria is carbon dioxide, which plants require. Neither plants no 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 a development has proceeded," said Hiram. "But we've every reason to believe that mutuall influential co-developments are as old as development. In their growing intricacy, they com to incorporate all degrees of cooperation—"

"Now you *are* drifting into metaphor," said Armbruster. "Cooperation implies conscio intent. Can you properly speak of cooperation among plants or animals that don't kno 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 Botswan told me about the honey bird, a drab little thing notable for being able to digest beeswax. can't get at honey or wax by itself, because it would be stung to death. So it enlists huma help by getting the attention of a hunter and leading him to a hive. The hunter overcomes th 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: smal skunklike mammals. Naturalists suppose these were the bird's traditional helpers. Sam routine: The bird gets the attention of one of these creatures, leads it on, the animal backs u to the hive, sprays it with his powerful odor, breaks into the hive, and shares its goodies wi 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 wor Even among human neighbors, where cooperation indisputably exists, it can be inadverten My tenant told me he misses me when I'm out of town because he depends on hearing m morning alarm clock—inadvertent cooperation on my part. The world's full of it. From no on, I'll just speak of interdependence, leaving aside whether it's intended or not."

"All this co-development, cooperation, symbiosis, interdependence," grumbled Armbruste "The three of you make nature sound like a barn raising, everybody pitching in togethe Where's the fierce competition? Where's the nature red in tooth and claw? Where's surviv of the fittest and devil take the hindmost?"

"Oh, competition's there, and so are winners and losers," said Hiram. "Losers die ar winners eat. The honey bird, skunklike mammal and hunter in Hortense's example a 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 or Put it this way: Competitions for feeding and breeding take place in an arena. The arena is habitat. The fittest panther in the jungle is a goner if its habitat goes. And what is a habita It's an intricate, complicated web of interdependencies."

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

"Yes," Hiram answered, "but first I'll remind you of the universal principles. Developme is differentiation emerging from generality. A given differentiation is a new generality, fro which further differentiations can potentially emerge. Thus the process is open-ended and produces increasing diversity and increasingly various, numerous, and intricate c development relationships. All this is the consequence of one simple sort of event repeate 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 wh should we care about them?"

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

“We should care about fractals,” said Hiram, “because lots of things that seem impossib to comprehend become more understandable if we identify the basic pattern and watch wh it produces through repetition. It’s a way of dealing with some complexities that otherwi 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 th universe toward intricacy and away from simplicity? But if the *why* of development impenetrable, at least the *how* of development is discernible, and this has practical value, n least for economic development—”

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

“Economic development displays the same pattern as any other development,” Hira resumed after their drinks were refreshed and Hortense, rummaging in the kitchen, ha produced a tray of crackers and cheese. “This is most obvious when the differentiatio 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 husbandr Human beings have deliberately developed hundreds of new varieties—although not ne species—of dogs, pigs, goats, and other animals, along with thousands of new varieties—a some new species—of edible and ornamental plants. They’ve done this by fostering desirab differentiations and selecting those worth further fostering. Have you ever tasted a wi orange? Awful, though beautiful. One of my clients has been developing cotton with col differences. No dye required.

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

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

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

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

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

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

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

"A major side-branch from the spoked wheel would bristle with the great family of rimle 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 oth unspoked wheels: the potter's wheel, the windlass, toothed gear-wheels, circular saw 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 tre from it emerged such differentiations as cane pressers, rolling pins, pulleys, rollers fo 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 whee explain little about spinning wheels. Spinning implies fibers for making yarn and looms fo using the yarn. Furthermore, your wheel lineages would make it seem that wainwrigh developed gear wheels when it's much more likely that windmill carpenters did, or eve makers of clockwork toys. And how could bicycle wheels have been made without wires an 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 th same reason as biological family trees: Its imaginary diagram is based on linear thinkin about development instead of web thinking. Development without co-development webs is a impossible for an economy as it is for biological development."

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

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

"The wreck of the *Titanic* makes essentially the same point Armbruster was making," sa Kate. "At the time the ship was built and when it embarked on its maiden voyage in 191 metallurgy hadn't advanced as much as engineering. Engineers had been able to design th largest man-made movable object, but the steel available to them couldn't withstand th stress of the vessel's size and it cracked under low impact with the iceberg. It was the be steel of its time."

"Icarus makes me shudder," said Hiram. "I'm nagged by thoughts of inventors ahead

their times. Sure, abalones demonstrate that it's practical to make first-rate ceramics at lif 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 Armbruste "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 Hiran "By that I don't mean random or inadvertent sharing but calculated, intended sharing as a institutionalized social practice. Along with us, our closest primate cousins, the chimpanze and bonobos, go in for deliberate, socially formalized sharing. This suggests that the practi may go back to an ancestor common to the three of us, back to prehominid times. As far economic life is concerned, the major differentiation that emerged from sharing was th practice of trading. A fossil form of English neatly records the developmental relationshi Old English had a verb meaning 'to give.' It also had a verb phrase meaning 'to trade,' whic meant, literally, 'to give with worth'—that is, give for a price. Our word *sell* comes from truncated portion of that phrase for trading, the part literally meaning 'give.'

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

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

"Old as it is, sharing is still a potent generality," Hiram continued. "Econom developments still emerge from it. According to a report I ran across in 1996, a thrivi cluster of commercial enterprises in Toronto ships old jeans to Cuba, coats to Russia, an ripped cloth to India to be recycled into thread. What's left goes to Montreal, the report sai to be recycled into upholstery for automobile seats. This recycled clothing is given by peop who are through with it. Sometimes they give it directly to the old-clothes sorters an shippers, and sometimes to charities, which sell it to the sorters. What's new about thes commercial enterprises is the convenient service they worked out for donors and the labo saving arrangements they worked out for themselves. They use phone calls or printed flie to inform householders of the days when they can leave their donations in front of the 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 the run by charities and some not, get first pick of the donations. The old-clothes sorters wh organized this efficient version of the ancient generality of sharing glimpsed possibilities fo 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 trading," said Kate. "But it's so unexpected. Yesterday I edited a little item for our comi 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 wir developed by Spanish jewelers in fifteenth-century Toledo. It got me thinking about obsole generalities—how even the most obscure and frivolous are potentially economically fertil provided that somebody who needs them can find them. Kinds of work are an econom equivalent of ecosystems' gene pools. So it would make sense to keep on the lookout fo 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 n threat of extinction. Buggy whips are a tiresome cliché for obsolescence. However, manu typewriters are rapidly going extinct, and I doubt that mechanics are still learning to repa them, let alone make them."

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

"Almost," said Hortense. "Saved barely in time. A few great-grandmothers still had th 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 th good, but what about humdrum work and products going extinct right now? Some of the not all that old, either. Armbruster, this record you're making right now could possibly soo be lost irretrievably. Fifty reels of taped interviews made forty years ago became importa to a Canadian investigative commission. Although the Viennese technology employed making and playing back the tapes had once enjoyed an international success, a international search turned up not one machine to play back those tapes. Control of the spee 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 fro ancient sites in caves and bogs. Computers have developed so rapidly that few are left whic can decode information recorded only twelve years ago. The 'Knowledge Age' is going t become the Lost-Knowledge Age unless preserving specimens of work is taken as seriously a 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 b going extinct, too, judging from cities that construct expensive transportation lines alon ridiculous routes, then wonder why they’re underused.”

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

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

“Thousands of years before anyone had a glimmer of evolutionary or biologic development processes, people were fostering differentiated strains of grains. Thousands o years before anybody was aware of symbionts such as mitochondria or chloroplasts, peop were combining materials and devices that had radically different economic lineages. Eve today, when educated people are aware of symbionts in the rest of nature, inventors wh combine silicon chips with typewriter keyboards—or any other devices and materials wi different economic lineages—aren’t imitating animal cells and mitochondria. Rather, they’r using universal principles of development and co-development for the good reason that n others are available. Economic development is a version of natural development.”

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

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

“However, if the development process is lacking in a town or other settlement, thing either given or sold to it are merely products of the process somewhere else. They don mysteriously carry the process along with them. To suppose that things, per se, are sufficien to produce development creates false expectations and futilities. Worse, it evades measur 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 tha others, whether by nature or nurture or both. Time and time again, it pops up in the mo