

What Counts is Where You're Coming From In Your Inner Self



Conversation with W. Brian Arthur

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Joseph Jaworski, Gary Jusela, C. Otto Scharmer¹

Joe Jaworski: We wanted to meet and talk with you because of something you said: that for the big decisions in life you need to reach a deeper region of consciousness, that it takes courage to listen to your inner wisdom, but once you hear that wisdom, making decisions becomes very easy. We're really interested in hearing your personal story as a way to begin.

¹ The conversation with Brian Arthur took place as part of a global interview project with 25 eminent thinkers on knowledge and leadership. The project was sponsored by McKinsey & Company and the Society for Organizational Learning (formerly the MIT Center for Organizational Learning). The interviews and the summary paper are accessible as free downloads from www.dialogonleadership.org.

I. Growing Up in Belfast

W. Brian Arthur: I grew up in Northern Ireland in Belfast. I went to university there, and grew up as a Catholic in a Protestant place. Being in the minority gives you a couple of things: one is the sense of being outside and a sense that there isn't a place for you, and the other is that it makes you an observer. If there is not a direct path you tend to sit and watch for your opportunities.

I've got nothing against Belfast or Ireland. It's got a dreadful reputation, but I find it a very warm-hearted place and have no regrets about coming from there. Life there is fairly tough and people are fairly tough and they have a very objective view of life.

My interests were in mathematics and engineering. I studied electrical engineering in Queens University in Belfast, and I entered University when I turned seventeen. It was ridiculously early. I wasn't mature enough. It was a very narrow education. In the UK system, things narrow very early.

C. Otto Scharmer: What led you to choose engineering?

W. Brian Arthur: I was interested in mathematics and physics, but I wanted to do something more practical. I didn't want to just be an egghead. I chose electrical engineering, but within a year or two I regretted it.

I was fifteen when I had to decide. My parents never went to university and nobody knew what engineering was. There was no career counseling. So I went there blind and discovered that I had no interest in engineering and no talent for it. I was top of my class with first class honors but I had no real interest in it. Then I went to England for a year. It was a huge cultural change. After a year there I transferred to the University of Michigan.

JJ: How were you able to do that?

UC Berkeley, 1969-74

W. Brian Arthur: I went to one of my professors and said I wanted to study in the U.S. for a Ph.D. He wrote down all the contacts he had alphabetically, and Ann Arbor was at the top of the list, Berkeley was next, and so on. I was lazy. I applied only to Ann Arbor, got accepted, and went there to study mathematics.

I was there from 1967 to 1969. I didn't like being in the Midwest so I transferred again, this time to the University of California at Berkeley. I arrived in Berkeley a week after People's Park — talk about journeys. Belfast erupted in August 1969 when troops came in. The next month I went to Berkeley, which was also erupting. The five years I spent in Berkeley spanned the time from People's Park to Nixon's

resignation. If I had chosen a five-year window from 1969 to 1974, I couldn't have done better.

A few years after I had been in Ann Arbor, I was looking for a summer job in the States and I couldn't get one because the Vietnam War was on and I was a foreigner. I had a professor who knew someone in McKinsey & Company. McKinsey hired me and sent me to Dusseldorf during the summers. I really loved that. The studies I was put on involved BASF, Volkswagen, Deutsche Bank, and a couple of others.

For me this was absolutely crucial. Imagine an education that consists of engineering, then mathematics, and then operations research, and then this counter-education in the background involving the political upheavals in Northern Ireland. I'd been brought up with a lot of political tension around, and I didn't want to be part of it, but I found I couldn't escape it in Berkeley. I wasn't part of it, but I sure stood by and watched. There were many, many close incidents, tear gassings, and so on. This was very real for us at the time.

II. Learning the McKinsey Method: Strategic Cognition

Then the other thing that was happening was McKinsey. I learned more with McKinsey & Company than I did in graduate school. McKinsey was interested in large amorphous problems, like what should be done strategically. At that time, companies in Germany were still organized along divisional lines. McKinsey's sophistication was very good.

In America, industry under Alfred P. Sloan's ideas was reorganizing into profit centers, so this is really what we were selling. To McKinsey's credit, it didn't go in there and just reorganize on day one. They went into large companies like Deutsche Bank, or BASF, and they just sat and sat. They didn't do anything. They just sat and observed and interviewed and observed and thought and went back and observed. It cost plenty to do this, but they were quite patient. **This would go on for months until they had what I would now call a complex picture of what was going on. The opposite of that would be to come in with some cognitive picture saying, "You need to be reorganized this or that way." They actually let a picture emerge**, and this wasn't lost on me. I would now call this an inductive rationality rather than deductive rationality. Rather than laying a framework on top, they simply let the framework emerge.

So strategic cognition was what McKinsey was good at. Somewhere along the line I absorbed all those lessons. They wanted me to come back and join in the firm in Germany and make my career there. In due course I probably could have been a partner, but I decided I wanted to go into science.

COS: What led you to do that?

W. Brian Arthur: I was studying operations research, and after McKinsey I lost faith in that too. Operations research was too mechanistic. I began to realize that the important things in business wouldn't be decided mathematically. Operations research is good for scheduling fleets of trucks or production lines, but when it comes to something truly important a wider cognitive vision first makes sense before you make decisions. That couldn't be done easily via the kinds of decision-making I was being taught.

To learn how to make sense of that, I transferred into economics at Berkeley. I was getting a Ph.D. in operations research, and I finished that, but I wanted to take a second one in economics. In those days Berkeley didn't allow two Ph.D.s. I did everything but a dissertation in economics and they wouldn't accept a second dissertation. They gave me a post-doc instead in the economics department. I'd been interested in the economics of third-world countries, particularly in the economics of population growth. I joined a small foundation in New York called The Population Council, on Park Avenue, and in due course I was sent to Bangladesh and then Kuwait and Syria.

Bangladesh: Doing the McKinsey

I discovered there that my scientific frameworks counted for nothing. I remember going down to the World Bank to the Bangladesh desk and coming away absolutely, totally unimpressed. [I asked,] "What's literacy like in Bangladesh?" Well, 23 percent are illiterate in this region and it rises as high as 27 percent. I said, "What does literacy mean?" They didn't know. I said, "In most Moslem countries it means that you can read a passage out of the Koran, and of course people may have memorized it. What about real education?" Well, they didn't know.

So I did a McKinsey in Bangladesh. I just sat there for a long, long time and did nothing until the whole goals and structure really surfaced. I was with a superb sociologist colleague, Geoffrey McNicoll, and we both did interviews, and thought, and sat on the edge of desks, and I reasoned that if this was happening, that must be happening. If that's happening, it might imply such and such. We were interested in landlessness and the incentives for child-bearing and so on. We cognized or structured that whole thing. We wrote an 80-page paper that later came to be seen as a classic on Bangladesh.

I got bored with that after a couple of years, and went to work in Vienna for five or six years.

Vienna, 1977-82

COS: When was that?

W. Brian Arthur: Nineteen-seventy-seven to 1982. In 1981 I was thirty-five, and I wanted to find a job in academia. I knew there was a chair becoming vacant in Stanford in population studies and economics, so I came to Stanford as a one-year visitor. I was hoping to get that chair, and indeed I did in 1982. I was in the department that dealt with third-world countries, the Food Research Institute. I had another appointment in economics. I had a chair in population studies and economics, the Morrison Chair. I was thirty-six and I had a professorship in human biology, not that I knew any biology, but I taught kids out of that department. That went on for a long time. I resigned that position in 1996. There's quite a long story behind it, but really it amounted to, as you were saying before, reinventing yourself.

JJ: Was there any sort of triggering? Was there any triggering mechanism at that point that caused you to want to reinvent yourself?

III. The Path to the Big Idea

W. Brian Arthur: In 1979 I started to read a lot of molecular biology. I was very influenced by a book called *The Eighth Day of Creation* by Horace Freeland Judson. It's a history of the discovery of the structure of DNA, and the discovery of how the genetic code worked, and the discovery of the structure of the hemoglobin molecule. I was fascinated. I started to read about enzyme reactions and the writings of Jacques Monod, a French molecular biologist and Nobel Prize winner. He'd written a book called *Chance and Necessity* where small events could get magnified by positive feedbacks and lead to different enzyme reaction paths. I began to realize that the counterpart in economics to positive feedback was increasing returns. I started reading the physics of positive feedback, and particularly the work of the German Hermann Haken at Stuttgart and the Belgian Ilya Prigogine, a man I am very fond of.

I realized that positive feedback in economics had to do with increasing returns. I realized that economists couldn't deal with increasing returns because they led to multiple possible outcomes. Basically, if there are several competing things and one tends to get ahead, it gets further ahead. Two hundred years ago the languages of Central Europe were French, English, and German. The more one was adopted the more useful it was to adopt that language, and given different set of historical events — say the victory of Napoleon overall — we might have all had to speak French internationally. There are several possible outcomes and historical accidents led us into the gravitational orbit of one of them. I began to see

mechanisms of positive feedback causing competing bandwagons where in time, one of several competitors could really start to take over and lock in.

I realized that the economists had avoided this phenomenon of increasing returns because they didn't like multiple outcomes. Schumpeter had said that unless an economics problem leads to a unique equilibrium outcome, it's chaos that is not fully under analytical control. And he was very upset about it. **I realized that what we had to do was to allow for the possibility of multiple outcomes. What I contributed was to map those sorts of problems into stochastic processes that were nonlinear.** I started to do a lot of work on nonlinear stochastic processes with some Russian probability theorists. This was June 1979.

COS: Can you describe the context of that particular moment when you got this intuition?

IV. The Moment of Epiphany

W. Brian Arthur: I'd taken a two-month leave to be in Hawaii. My wife had just finished her Ph.D. and I went to Hawaii. I was reading a great deal of molecular biology. Normally I read physics. If there was a moment of epiphany, it was in June 1979 when I read a little essay that Prigogine had written. **I forget what he called it, but it covered everything from the way termites build nests to the phenomenon of languages taking over, but it was about positive feedback, and instantaneously I realized I had something that was important in economics. All I needed to do was figure out how positive feedbacks worked in economics, and it took another ten years to do that. But suddenly, within about two or three weeks, everything in economics fell into place for me.** It was a period of very, very intense intellectual excitement.

JJ: Did this germinate in Hawaii when you were out there?

W. Brian Arthur: No, but the scene had been set in Hawaii. That's where I had been reading all the molecular stuff. It was about two months after that; I'd been totally primed. I think I read Monod's book, *Chance and Necessity*. A lot of things happen by chance. Some things happen by necessity — deterministically — but with positive feedback, the necessity magnifies the chance. It locks things in. I began to get a very good feel for positive feedbacks, and I realized that the counterpart in economics was that small events can lead the economy to quite different structures. You know, if Napoleon hadn't done such and such on the morning of Waterloo maybe, dot, dot, dot.

I realized what was missing was the methodology, and I knew where to get it. I had to delve deep into nonlinear probability theory. It took me years to do this and

I'm still not very good at it. I'm not a professional probability theorist, but I had to get good enough to work on a level with real professionals.

Big Idea = Big Threat

The other thing I realized was that when I floated this around, economists got threatened and I got scared. I had the ball and the net was wide open. I was goal shy because I knew there would be hell to pay. **I was saying that small events can lock the economy into different structures and that it's fractal — that there are structures within structures, that the entire economy isn't the best of all possible worlds. Capitalism does not lead you to the best of all possible worlds.** This was regarded as a supreme threat. It was the middle of the cold war. There was a lot of ideology — it was the Reagan-Thatcher years — and the whole edifice that had been built up for 200 years was threatened. You couldn't do economics statically anymore. The equilibria that manifested were not the best of all possible worlds. Markets were not perfect. Small events could lead you to inferior solutions, and I knew there would be hell to pay. What I didn't realize was just how much hell had to be paid. So I wrote this up, waited for two or three years, and then wrote it up [again] in 1982. I couldn't get the articles published.

JJ: After you wrote this, you couldn't get any of the articles published?

W. Brian Arthur: No. In the first ten years of my career in economics, I published many articles and got a chair at Stanford. During the second ten years I published one article. In the end, that led me to leaving Stanford.

JJ: But this is the story of any entrepreneur, you know, somebody who is willing to go ahead and take a stand and then they pay hell.

How Big Ideas Happen: An Archetypal Journey

W. Brian Arthur: This is true, but I didn't know this at the time. I've read a lot more history of science. I wish people would tell you in high school. You think somebody gets an idea in their bathtub or the shower and everybody realizes it's valid immediately and you're led on people's shoulders down the street with the crowd cheering. It's not at all true. So I couldn't publish and I spent the next ten years in a professional hell, but I kept writing. The support I got was always at the very top.

JJ: And where was the article finally published?

W. Brian Arthur: *The Economic Journal* in England, but I sent it to the *American Economic Review* and the *Quarterly Journal of Economics*. They couldn't find any technical fault, you know, why this isn't economics or whatever. It was a horrible period.

COS: What kept you going? When everything was turning against you, why did you continue on?

W. Brian Arthur: I thought it was deep and I thought it was right and I thought it was about the deepest thing that had happened in economics in a good while, and I still think so. It's a totally different way to look at things. That kept me going. I also had support from Kenneth Arrow at Stanford and a few [other] people. Arrow gave me a Guggenheim Fellowship in 1987.

I had support from Tjalling Koopmans and Kenneth Arrow and a layer of Nobel Prize winners. They were open-minded. It was one layer down that was the problem. I've no regrets, but it was a very horrible period of getting rejections back and being regarded as a charlatan and a pariah. At the end of my years at Stanford I was probably less employable than I was at the start. You know, to this day, I'm not sure a respectable economics department would have me because there is always a minority that can block an appointment. This will not be true forever, but it is true now.

V. Santa Fe Institute

Arrow brought me to the Santa Fe Institute in 1987. And Philip Anderson, who is a physics Nobel Prize winner, sprinkled holy water on all the ideas.

JJ: That was in the early days of the Institute.

W. Brian Arthur: Yes, very early. They hadn't really started. It was August 1987, and I gave a talk there in front of twenty people. It was a who's who of economics and physics. The economists bristled at what I was saying. The physicists just sat there nodding. Phil Anderson said, "I thought economics was dull and boring, but this stuff speaks to us." So after that I was brought back to the Santa Fe Institute in 1988 to start their first research program. I was backed by John Reed from Citibank, who gave us a lot of money. There was no other research at SFI, so I set up the first research program and was able to set a lot of the style of how things were done there. No departments, no students, and a very open atmosphere of just throwing out ideas and going to the fundamentals.

John Reed was saying, "Do anything you want, just don't be conservative." Arrow and Anderson also said do anything you want. I said "What precisely do you mean?" "Go deep into the foundations and change anything you want."

JJ: So this was a brand new opening at the Santa Fe Institute?

W. Brian Arthur: Yes, and that saved me. I set up the first research program there. George Cowan, president of SFI, took a huge gamble on me. Bob Solow and others at MIT told Cowan he had made a dreadful mistake, that I was nobody.

George backed me anyway. I could pick anyone I wanted to bring to Santa Fe, so I brought John Holland and Arrow and Frank Hahn and others. These people were heavyweights and I was able to put the problem to them: If you had to rethink economics, what would it look like? And that is what we did. I don't know how it will shake out. This is what I'm good at — to take something amorphous and figure out how it works.

The Inner Journey

I think these are patterns that are common to many people's lives, especially if you're a bit older. In the atmosphere of the '80s I had everything anyone could want, but I was profoundly unhappy. I wanted to do this sort of work and nobody would publish it and listen.

Then in October of 1986, my wife, who has a Ph.D. from Princeton in mathematical statistics, got deeply involved in Buddhism. I couldn't make head or tails of it, but I was interested. I'd been brought up Catholic. I had renounced that in my early twenties. I became agnostic and had a kind of scientific-engineering agnosticism. In 1975 that started to change. We traveled through India and Katmandu. Suddenly I began to realize that there was a dimension out there that was trying to shout to me but I'd nothing to hear it with. I started to read Carlos Castaneda's books. Like a lot of people in those days, not only did I read them, but I reread them and reread them. I don't know where they are now, but they're all marked up and absorbed and digested.

VI. Taoism and Economics: Mechanical Order vs. Unfolding

COS: How do Buddhism and Taoism relate to economics?

W. Brian Arthur: Standard economics is very good for being shoehorned into an image of 19th-century physics. It was precise and accurate and static; it concerns itself with equilibrium. I began to realize that what really interested me was to see the economy not as static but as unfolding, and as patterns that were always unfolding.

I began to realize that if patterns were always unfolding it gives you two questions or problems. The economy is always unfolding, and at a more fine level business is always unfolding. John Seely Brown says if you leave your job for a couple of weeks and come back, the whole atmosphere is different. He's exaggerating, but you know the game has changed. So let me try and contrast that with a different view. The standard way of looking at cognition and decision-making is very different from this other view I stumbled upon.

You were asking how that fits. **If you ask Taoists how they see the world, the first thing they'll tell you is that the world is changing. Everything is always changing, everything is always unfolding, and it is our job as human beings to allow things to unfold.** You can give a little nudge here and a nudge there, influencing things at the proper time in your own way, but the world is not seen as a machine. **The world is seen organically as a collection of unfolding patterns.** When I worked on my economic increasing returns theories, before I studied Taoism, I gave a talk at the University of Hawaii in 1985 and a student from the Chinese mainland came up to me and said, "All that you say has been said before." And I said, "All right, give me a citation." He said, "It was all said by Lao Tzu." I said, "In that case, I'm honored."

Taoists see the world as patterns that are unfolding. I've gone back and read Sung-Dynasty Taoism and Neo-Confucianism. Cheng I, and Cheng Ming Tao, and various others writing and teaching in the late 1000s. It's remarkably contemporary. They taught that all was in flux but that everything structured itself according to inner principles that governed it. Now we'd call those laws. **They said principle is one, but its manifestations are many. In other words, things in this world emerge from elements that structure themselves. The mind, they said, is not a vessel to be filled with facts or ideas. It too emerges. The mind is an emergent phenomenon.** All this they said a thousand years ago.

Complexity Theory

Let me talk for a moment about complexity theory. It's really a movement of the sciences. Standard sciences tend to see the world as mechanistic. That sort of science puts things under a finer and finer microscope. In biology the investigations go from classifying organisms to functions of organisms, then organs themselves, then cells, and then organelles, right down to protein and enzymes, metabolic pathways, and DNA. This is finer and finer reductionist thinking.

The movement that started complexity looks in the other direction. It's asking, how do things assemble themselves? How do patterns emerge from these interacting elements? **Complexity is looking at interacting elements and asking how they form patterns and how the patterns unfold. It's important to point out that the patterns may never be finished. They're open-ended. In standard science this hit some things that most scientists have a negative reaction to. Science doesn't like perpetual novelty.** I once asked John Holland, who's knowledgeable about chess playing, if chess has reached some sort of equilibrium where if everyone plays their best, games are lost and won, but chess overall does not progress. He said no. There is novelty in what's discovered century by century in chess. A good tournament master now could possibly beat a grand master of a

hundred years ago because the envelope has been pushed out of what's known. **So anything complicated and interactive seems to unfold and develop new structures.**

The Mechanistic View of the Old Economy

Now switch to business or the economy. The old thinking is that business and the economy are mechanistic. People talk of linkages, that things have to be "on the right track," that we need to fine-tune things, get it up to speed. If only we understood the mechanisms, we could fine-tune the economy. At deeper levels in business there are decision-makers, agents, and at any time each agent faces a set of problems, probably with a capital "P," and to those problems there are Solutions. **This just happens to be a structure we laid on business, trying to make it a science. We believe there are Problems and there are Solutions.** Implicitly it means that if you are managing there is a feeling here that you can actually frame the problem correctly so that there is a Solution with a capital "S," and it's up to you to learn how to arrive at that solution. But all this only works in repetitive business, where you can optimize and the problems are well defined. **It appears in that case that management's problem is to optimize, to get it right. Lower costs, get quality up, keep everything moving, make it smooth, make things reliable, solve the problems, and find solutions. That's old thinking.**

The World of the High Tech Economy

Let me contrast that with high tech. This is an article I wrote in the *Harvard Business Review* a couple of years ago, August 1996. **There are several things that are different about high tech. One of them is that there are typically increasing returns, network effects, and upfront costs. So if you are the people who invented Java, you can make billions if you can lock it in. If you can lock people into doing documents digitally by Xerox rather than Canon, you can take most of the market. This is typical. High tech in my metaphor tends to be much more like a casino.** It's not the halls of production in repetitive industry, but rather the casino of technology. There are many tables in this casino. And at each table are different games. At this table we're going to start up digital banking, and the outcome of the game is that two or three of the key players are going to take 90-something percent of the market. So this is not a situation where everyone gets 10 or 15 percent market share. You typically find 80 percent market shares, 70 or 80 percent, like CompuServe or Microsoft have in their markets. The next player might have 20 or 30 percent, and then there are a few bit players. **This is because there are increasing returns and diminishing costs, and the more advantage you have the more advantage you get. The more people who use Windows, the more likely I am to use Windows. But it could have been some other operating system.** When there is competition in this area, through those

sorts of network effects or upfront cost effects, a winner will lock in most of the market. With Windows 98, the first disk will cost me maybe half a billion dollars and the second will cost me two or three cents. So the more I put out the cheaper my unit costs are. Therefore, the more market I take the more cost advantage I have. The more people are using that then the more that creates a network of users and so on.

Winners Take Most

So in competitions in those areas, the winner takes most. This sets up a totally different set of problems for management. The problems are not optimizing ones. You're sitting at this table and starting up in digital banking. You don't know what the technology is going to be. You don't know who's going to sit at the table so you don't know who the competition is going to be. You don't know what the government regulations are going to be. You don't know how the technology will work out. You don't know how it's going to be received by the consumer, and you don't know whether it will work. You don't know how consumers will take to it. You don't know what ancillary technologies are going to be used and what alliances people are going to cobble together to make it all work.

And so, the point I want to make is that there is no well defined problem with a capital "P." Imagine it's five years ago and you're thinking about Bosnia. You're in the State Department or the UN and you're going to put in a UN peacekeeping force. **If I said to you, "Optimize the problem in Bosnia," you'd say, "What problem?" I mean, clearly things aren't right, but is there a *correct* problem? Does a problem exist? No. I don't mean there is *no* problem, but there is no *correct* problem. All you can say is that you have this situation and there are many ways to cognize it.**

These situations have a Rorschach inkblot feel to them. You have to read the problem into the situation. If I'm sitting here in Silicon Valley, it's not that at any day I might have a particular problem with a capital "P." My supplier may not have sent me whatever processors I need or backup memory. That's a problem, and maybe you can do something about it. But what I'm facing more typically as an entrepreneur or business person is a set of *situations*. **And what I'm trying to do is to make sense of these. John Seely Brown says the challenge in the old economy is to make product. The challenge in the digital economy is to make sense.**

So in a sense there isn't a problem; there is a situation or a set of situations and they continue to unfold. And your job, should you accept it, is to make sense out of it.

It's like your own life. If I said to you, what's your problem? You'd say, I don't know. Is there a correct problem? No there isn't. You could get banks of therapists

and go deeper and deeper. So you have a set of situations you're facing. And there might be less appropriate or more appropriate means of dealing with these.

VII. The First Thing You Do Is Observe

W. Brian Arthur: You can approach this from the point of view of complexity or economics or Taoism; certainly try all three.

From the economics side, think of your own life or Bosnia or Belfast or high tech: You're in a situation and varying conditions can be put in that.

Cognition is never extracted from the situation. You don't make sense from the situation, you impose sense upon the situation. Confusion is the absence of the framework, and known confusion just means that you have framework. You can label it. **We have a nice saying in Belfast, "If you are not confused, you don't understand anything."**

So what is facing management in high tech is confusion. The job of management in high tech, at the highest levels, is not to manage but to find frameworks. Once you have frameworks you're willing to impose, they imply the appropriate reactions. Not optimal reactions, but appropriate. So you can't optimize in this area. All you can do is to act appropriately.

Switch then to Taoism. Taoism keeps saying that the world unfolds. There is no truth. There is only that which you impose upon it, and you can't move the world. But you can move yourself appropriately. So the way Taoism would inform martial arts is to say you don't know what your opponents are going to do, but when your opponent moves you can react appropriately.

So you don't have to face 4,000 pounds coming at you head-on. You should be able to move to the side and deflect it. This way of thinking would say that there is no correct solution. You allow the world to unfold and you act appropriately.

So I'm sure you're beginning to see why I say the first thing you do is observe.

JJ: It's totally, completely understood.

W. Brian Arthur: Okay. Or think of driving at night. You're driving on a narrow road in New England late at night with your headlights on. There might be deer or animals on the road. It has just snowed and there may be a little sheet ice out there, you're not sure. What problem are you solving? There isn't a problem. You're not optimizing anything. You're actually cognizing your feeling, you're working from here, not from the head. Moment to moment you're recognizing what you're in and saying, "It felt like black ice going around that last corner and

that wasn't true half an hour ago, therefore I should do such and such." You are conforming to what's arising, but not in a passive way. **You are pre-positioning yourself.** So in that sense it's all about the position.

This is the case with Taoism. Taoism doesn't tell you to optimize your life. It doesn't tell you that life is going to be happy. It just tells you that the world is always changing. It doesn't tell you to mutely conform in a passive way, but you shouldn't struggle either. You just go with whatever it is, and at each stage you put your all in appropriately.

Complexity

The third thing is complexity. When you start to take the world seriously from the complexity point of view, you begin to see that organisms are in a world of continual change. If you look at a species in an ecosystem, the ecosystem is much more changeable than we ever supposed. I was watching "Nova" a week ago and they were saying that we're in a period of remarkable stability. This wasn't true ten thousand years ago, when there were huge changes worldwide. So it's hard to talk about optimization or that a species is optimized. Everything is mutually adapting to everything else all the time, and the complexity point of view asks how things adapt to various circumstances.

As we shift into a high-tech economy, making sense of situations and then taking appropriate proactive kinds of actions counts. This is opposed to the pre-high-tech economy, where the situation was unchanging, problems could be well defined, and therefore optimal solutions were possible.

A totally different set of rules apply in this new environment. You hang back, you observe. You're more like a surfer, or a really good driver at night. You don't act out of deduction; if you do, you're going to get creamed. **You're acting out of an inner feel, making sense as you go. You're not even thinking. You're at one with the situation.**

Taoism

Let me go back again to oriental thinking, to Taoism. In oriental thinking, you might just sit and observe and observe — and then suddenly do what's appropriate. You act from your inner self. Traditionally, Chinese and Japanese artists sit and look at a landscape. They'll sit on a ledge with lanterns for a whole week just looking, and then suddenly say "oooohh" and paint something very quickly. Consider a tea ceremony. With deep training and deep observation, you're reacting appropriately, and the appropriateness of the reaction depends upon the degree to which you are at one with the situation. It's the same with martial arts: **If you have to think in martial arts, you're dead.** The twenty or thirty years of

training you've had mean that you've internalized lots of possible patterns and instinctively know how to react.

VIII. Management in the High Tech Economy

This has a lot of implications for management because it's saying that what counts is where you're coming from in your inner self. Now imagine you take a CEO out of the processing industries who has optimized Pepsi-Cola, for example, and you put him in Apple Computer. What's he going to do? He will bring that one sort of cognition, "cost down, quality up" or whatever the mantra is, with him and that's it.

Now think about Steve Jobs and Bill Gates. When Jobs came back to Apple he said, "Well, the reality is the Internet now. What are we going to do about it?" He turned Apple around. Gates and Jobs are good at very different things, but they both know how to distance themselves from the "problem" and expose themselves to something different. You wait and wait and let this experience well up into something appropriate. In a sense, there is no decision-making. What to do just becomes obvious. You can't rush it. Much of it depends on where you're coming from and who you are as a person.

JJ: Right. I totally understand.

W. Brian Arthur: It's true of first-rate scientists also. The merely good scientists are able to take existing frameworks and overlay them on to some situation. The first-rate ones just sit back and allow the appropriate structure to form. My observation is that they have no more intelligence than the good scientists do, but they do have this other ability, and that makes all the difference.

You can see this in business as well. Sam Walton didn't just use some old framework to create Wal-Mart. He said "Well, hang on here. We've got computers, we've got inventory, and we've got a whole network, so what are we really trying to do?" It may take months or a year to figure that out. You cognize things or piece together the framework from a different perspective, and if it is appropriate then it works.

This has very practical implications. Suppose I'm a large New York bank and I want to set up digital banking. The worst thing I could do is to bring in somebody who has been successful from the processing industries. They'd come in day one with a ready-made framework and say, "Okay, we need such and such and this is how it is going to work and it's going to be like this and such."

That's appropriate if the problem is conventional, but it would be better to get someone who says, "Hmmm, digital banking, we've never seen anything like it. What's really going to count here. Who is going to be in it? What will consumers

accept? What is the government going to do? Is this when you take all or nothing?" If that person is any good, they'll be acquisitive and take a piece from here and a piece from there. They'll think, "The early days of such and such worked this way. If we look at digital banking like software, we can expect this. If we look at it as X , this might happen." Cognitions are built up piece by piece from the first principles.

JJ: Can you help me understand what you mean by "cognitions"?

Cognition

W. Brian Arthur: I view cognition as a framework that one would associate with something — for example, if you see someone and all you are seeing is pixels upside down in your brain. But the brain is structured so that certain features of the pixels trigger an association, and the association starts to trigger certain labels and you say, "Oh, that's old Fred, my friend," or somebody. That's a cognition. You've brought a set of associations to an amorphous pattern, and those associations can be quite metaphorical: "Oh this is just like Munich in 1936." It can be almost primitive associations: "This is my dog. It's not just that fuzzy set of brown pixels that are in my brain. This is a dog, and moreover I know it's my dog and I saw it this morning." We do that with various degrees of sureness.

I don't know if you remember those 3D patterns, where if you stare at them all you see is patterns, and then suddenly if you stare long enough, a three dimensional aspect comes out. Now what's happened cognitively? The three-dimensional aspect didn't come out of the paper. Certain physical things happened within certain sub-features inside your neurosystem that imposed an understanding of three dimensions, or a framework of three dimensions, on that paper. Moreover, it fits because if the 3-D was random it wouldn't jump out at you. There is a consistency to the pattern. It looks like dancing horses or something. It fits with other associations. The horses look like horses. So cognition is an imposing of understandings and an imposing of previous associations. You know it is cognition when you hear someone use the phrase "it's like." So if I describe something, I'm asking for a cognition, "Well, it's like this; or, here's what he's like." You are searching for all the associations.

IX. Accessing the Deeper Levels of Knowledge and Knowing

COS: When you made the distinction between the good scientist and the first-rate scientist, you said the good scientist takes an issue or a problem or a situation and then imposes a framework on it. Then you said the first-rate scientist would do something else. They would expose themselves to the situation and wait until the

pattern emerges. So what's the difference? Isn't that a different type of cognition than what you just described? Where does that come from?

W. Brian Arthur: This is a good question. A good scientist says, for instance, in economics, "This is the principal-agent problem, this is a game-theory problem, this is an overlapping-generations problem." In fact, graduate studies in any of the sciences and economics consist of teaching students thirty to fifty different cognitions until they've mastered them. Then they learn to apply that, and later, when they're working for the World Bank, they can say, "Okay, it's like a principal-agent problem." If you get good enough at this, you actually forget the labels and internalize it. You just have an inner feeling. I'm not saying that's bad. That's done, and there is an appropriateness to it.

First-rate people are saying something deeper. They wait and they don't say anything. They go as deep as they can. They're examining fundamental beliefs and saying, "Well, I could really move this company as a shrink-wrapped application, but it needs a lot of change." A first-rate person says, "Is that what we need to do? Is that the business anymore? Hasn't it changed, and aren't we really going to get into such and such?"

The way you can tell what the difference is that in the first type of cognition, the new business world becomes an appendage of the old. Encyclopedia Britannica CD becomes an appendage of Encyclopedia Britannica leather-bound volumes. But if you wanted to cognize that business appropriately in 1991, you'd have said "Encyclopedia content is just software. It will all be available on CD. Volumes are nice for libraries and people who like to have that around their house, but the real business is going to be selling these things and that should be done separately. The leather-bound books ought to be an appendage." It's like a gestalt switch.

First-rate people go to the root. They don't just ask what's appropriate or what appropriate framework can I dig up and impose. They will study the situation from many, many angles and then say fundamentally what really is going on here. They may borrow ideas and cobble together a very different framework.

There are many types of understanding. It may be that there is an overall simple type of understanding where you just say, "Oh, they've got an inventory problem here." Then there is the deeper kind of understanding I just talked about that asks, "What really is the problem here?" The first type of understanding tends to be the standard cognitive kind that you can work with in your conscious mind. But there is a deeper level. Instead of an understanding, I would call this deeper level a "knowing."

JJ: Yes.

Sources of Inner Knowing

W. Brian Arthur: The inner knowing comes from here [pointing to his heart]. Every one of us has experienced this in different ways. You may not be conscious of it, but you have.

I remember being on the side of a mountain one time in Santa Fe. The sun was setting and I was a third of the way up and I thought, "It's time to get off and come down. I don't want to break an ankle or something." But then I had a feeling that I ought to go on up the mountain. The sun set, and the moon rose, and it was dark, and I couldn't see the path. I had been doing a lot of training at that time, and I think I had a knowing that I should go up the mountain. Within that, I had a knowing that if I couldn't see the path it was likely I would kill myself. There was quite a sharp fall-off at the side of the path. But each time I didn't know where to go, all I had to do was stop and ask here [pointing to his heart]. That was a knowing, and it was never wrong.

JJ: I totally understand.

W. Brian Arthur: I don't know or can't say where these knowings come from, but I tend to go back to oriental thinking. The Japanese and Chinese would say that everybody has these abilities, and the reason that a Japanese management trainee would go off and do Zen training is because that is considered to be cultivating yourself as a human being. One practical reason is that it allows you to get in touch with your inner self, this deep inner knowing. This is something the West doesn't have much patience for. All I can say is this: When it is a knowing, you really know and it's a total conviction. It doesn't mean that I know everything that is going to happen or I know what mutual fund to put my money in, though sometimes I do get convictions that seem to be deep, and you know, you always ignore them.

Suppose I was parachuted into some situation in Silicon Valley. It's not a problem, it's just a situation that is complicated and changing and unfolding. I'm trying to figure things out. **I would observe and observe and observe and then just retreat. If I'm lucky, I would get in touch with some deep inner place and then allow that knowing to emerge.**

JJ: You know, that's what David Bohm told me. He told me that this is the way to operate.

Coyote Café, Santa Fe

W. Brian Arthur: Yes. In a sense there is no other way to operate. One time Phil Anderson and I were sitting around in the Coyote Café in Santa Fe and somebody says, "Hey Phil, you play chess?" "No." "Do you play checkers?"

“No.” “So you’re not any good at that sort of thing?” and Phil says, “I play Go.” “Oh,” I said, “Phil are you any good at Go?” And he says, “Yeah, I’m not bad at it.” “How good are you Phil?” “Well,” he says, “there are four people in Japan that can beat me.” So you say, “Why did they beat you Phil?” He says, “They meditate.” And I told him “So, they’re coming from an inner place,” that inner place of knowing. But you see I’ve run out of vocabulary.

JJ: There’s no way to give voice to it. I just wanted to hear you try to give voice to it because I believe your whole experience was saying that to me, and that’s why I asked the question about the cognition. There is another place . . .

W. Brian Arthur: Well, there is another place, and I think that place is to retreat deep, deep, deep into essence and then let things emerge. The distinction people often make is that this is not doing, it’s being, and our culture here is one of doing. The question is not “What are the appropriate actions?” but “What is the appropriate being?”

JJ: Exactly. This is the true point. This is why we came to see you. That’s exactly right. It’s all about being. Leadership in business is not about doing, it’s more about being.

W. Brian Arthur: It’s an expression of inner being. I’m just amazed sometimes. I bought my daughter an iMac and I have a G3 myself — they’re both Apple computers. I look at the select feature and I think, “This works beautifully. Why does it work?” Like a lot of people, I have had many computers. But what is it that’s so nice about the G3? There’s something lovely about it as a piece of technology. It actually doesn’t have to do with decisions; it has to do with the inner being of Steven Jobs. There’s an elegance to anything he touches, and that’s a function of being. It’s what he’s about. What he’s about is technology. Gates is not about technology, so anything that comes out of Microsoft is usually mediocre in terms of technology. Gates is about something different.

Listening to the Inner Place Where Knowing Comes to the Surface

It’s hard to find language for this. Someone like Csikszentmihaly talks about getting the flow, and flow has to do with things just unfolding, with listening to that inner place where knowing comes to the surface. It’s like when I knew I had to leave Stanford. I had an inner knowing. Something tells you that you ought to do such and such.

Gary Jusela: There is something that occurs to me about some of these stories you’ve been telling that’s a paradox to me. You talked about what might happen in leadership development in Japan. They go off and do this deep Zen-like meditation or actual real Zen meditation. What you’re describing in that sense of going into your essence runs so counter to our culture here in the U.S., and yet there is this

pattern-recognition thing going on here and not going in Japan it seems, economically in terms of finding this new chapter. Doesn't that seem paradoxical? What's going on? They have the means. Japan is coming out of this deep oriental tradition along the lines of what you're describing. This place is like pure rational science in a lot of ways, and yet there also is some other overlay. So how do you explain that?

Two Levels of Knowing

W. Brian Arthur: If you get to a very deep level of knowing, like some high Rinpoche or Taoist master, it doesn't mean your knowing is about what would be immediately applicable in a modern world. If it did, the Dalai Lama could set up a lot of high-tech companies and make a lot of money. Again, I'm in waters here that I don't understand or normally talk about.

Level 1 of Knowing: Knowingness Arises from Immersion

Maybe there are two different levels, but one deep level is when you have been so immersed in an area that it informs every fiber of your being — martial artists or oriental artists strive for this. **They absorb and absorb and absorb and then they forget, and it becomes an inner part of their being and the knowingness can arise out of there. That's one level.**

Level 2 of Deep Knowing: Knowingness Arises from Grace

I suspect there is an even deeper level that the West might call grace. I don't know what you'd call it, but these knowings don't necessarily have to come out of years and years of previous exposure.

So to come back to your question, I think the Japanese have a deep, deep inner cultural exposure to precision. They had it with ceramics. They had it with the types of art that were done, and so it was natural when the transistor came along and high-precision optics and high-precision plastics and high-precision processing in manufacturing, that they would be very good at that because they had centuries of that kind of cultural knowing. It doesn't mean that they're good at what counts here, which is combining different elements into something else. That's a very different set of skills. And again, I'm not sure how that comes out of the California culture, but it's certainly here.

GJ: Right. There is something spiritual going on here, in terms of a level of spiritual knowing, that's not just pure "traditional" science. You're talking about a different kind of science here.

W. Brian Arthur: Yes. If I did get the right answer and I'm sitting in a Zendo in Japan and it's "Ahhh, yes, Internet company of Zen, aaahh." And you leap outside and throw away your Zen stuff and where are you going to get the infrastructure, where are the venture capitalists? You're right by Sand Hill Road here. Where are the patent lawyers [in Japan]? You can do it [there], but immediately the third parties would cognize it into what they deal with in Japan. They'd say, "Oh, you're trying to do such and such. That's just like microprocessing of such and such a kind and we've done that." Immediately they'll shoehorn you. So what's going on here is a subconsciously understood culture set of reactions so that if you do have an idea, you will have an appropriate infrastructure for that idea.

X. Sensing What Is Wanting To Emerge In the World

JJ: I want to tell you that the things you're saying are really profound. I was just so struck by what you said because Martin Buber, the existentialist philosopher, writes about it. He said:

Free is the man that wills without caprice. He believes in the actual, which is to say: he believes in the real association of the real duality, I and You. He believes in destiny and also that it needs him. It does not lead him, it waits for him. He must proceed toward it without knowing where it waits for him. He must go forth with his whole being; that he knows. It will not turn out the way his resolve intended it; but what he wants to come will come only if he resolves to do that which he can will. He must sacrifice his little will, which is unfree and ruled by things and drives, for his great will that moves away from being determined to find destiny. Now he no longer interferes, nor does he merely allow things to happen. He listens to what grows, to the way of Being in the world, not in order to be carried along by it but rather in order to actualize it in the manner in which it, needing him, wants to be actualized by him — with human spirit and human deed, with human life and human death. He believes, I said; but this implies: he encounters. (Martin Buber, *I and Thou* [trans. Walter Kaufman] (New York: Macmillan, 1974)

What I was hearing when we were talking is that the work is to sense what it is that is wanting to emerge in the world. To be very aware and sensitive to that and then to be able to actualize that as it desires. Does that make sense?

The Key to Living An Active Life: Surrendering

W. Brian Arthur: Yes, absolutely, totally. I'm in unfamiliar territory here because my thoughts are about economics and some about business. I'm not sure I have thought much about spirituality, but I've certainly been through a lot. I've never tried to put them all together. **I think in some strange sense the absolute**

key to living a very active life is to surrender; and what Buber says there is that it is not your own will, it's a higher, deeper will. In some sense I think that one has to say, "Look, I'm here. I'm willing to do whatever is necessary for whatever reason. I'm here and give me the chance to do it and the means and I'm willing. The problem is I think that you can talk about inner knowing, but my instinct is to try to get ahead of that and say, "Therefore, here's how you can train management." This is really your area more than mine. I haven't thought much about that, and I'm not sure how one could do it or would do it. I can sense certain things. And I can say that I've seen many, many things that I could not explain by supposedly rational means.

At the Bottom of Science Is the Unknown

In all these sciences, there may be rivers of thought, and if you track each one back to its source, meaning the primitive concepts, you're in the unknown. In physics, for example, you can track it all back to energy and really fundamental sub-particles like quarks and then further back. When you get back to those source concepts you're in the unknown. We don't know why there is energy. We don't know what quarks are. We don't know anything fundamental, and it's a conceit that says science understands. It doesn't. It starts with a few magical unknowns. It starts with the unknown and labels part of it and knots a few strings below that and then hangs onto those strings, but they're not suspended from anything.

JJ: That's so important.

W. Brian Arthur: It's the same with chemistry. When you start to get into the nature of chemical bonds, you're back to the same problem of energies and so on. It's the same in economics.

I asked a friend of mine who is a philosopher why all I do these days is read philosophy. I can't stand reading economics anymore, but I did twenty years ago. He said, well, **if you drill deep enough into any subject, you get into philosophy.** But philosophy is our way of coming to grips with the unknown. Philosophy isn't about the known. Philosophy is about the unknown. Philosophy is like scouts that we send out to explore new territory.

The point I want to make with all of this is we've constructed this edifice called Western science that happens to be good at a few things like CAD imaging, or guiding satellites or nuclear bombs, but it doesn't mean we really understand the world at all. The only people who think we do are people who don't understand science. People like Bohm or Einstein, who really do understand science, will tell you that there is a thin layer of what we do understand, but down below or above it we don't know what we're in.

Once you see that, then I don't see why there should not be fields or areas of understanding that don't have much to do with the cognizing process. This is something that I would never stand up and say. It is certainly my own belief. I've seen far too many phenomena that I can't explain, and I don't even know where to begin.

I don't know where this would go with management. Images come into my mind of actually having people stop, calm down, sit, and let things emerge. Like if you're forty-five and you have a mid-life crisis or something, and you go off to some island for two weeks. Maybe nothing happened there, but you may come back and say, "I need to change this and this. I'm not happy in my job," or something like that. I think that that is really good.

The current view is that the world is deterministic and mechanistic and that certain modalities can operate, problems, solution, subject, object, and so on. We tried, during the 20th century, to push those views into mathematics and physics and, for that matter, economics. Each place we pushed, it ran up against its limits. Certainly in physics, quantum theory, fundamental particle theory, in economics, the whole crashes upon itself similarly in philosophy. Wittgenstein tried to push it to its limits with the *Tractatus*. In his later philosophy, he had to let go of the idea that you could mechanize philosophy and make it into a logical consistent apparatus like a mechanical apparatus.

The Root of the Mechanistic View: The Catholic Church

Interestingly, all that came not from Descartes, but the Catholic Church. The mechanistic view came from the Church. In the early 1600s there were a lot of pantheists still in Europe, and Christianity was progressing. The Church thought it could do out the pantheists by saying the world was a mechanism.

There are corpuscles in the world, and those corpuscles (maybe we call them atoms) operate mechanistically. Everything is precise and there is one God operating that.

The Other View: An Organic Perspective

The pantheists' point of view is that the world is organic. It all has its own spirit. Every stream or riverbed and tree and so on. They wanted to do away with this.

I think we're currently going around one layer of a spiral. We have deeper understandings because of three or four centuries of science from Michelangelo, Galileo, and Descartes. But as we push up against the limits of the mechanistic view, we are finding that we're coming back to the organic view that everything is unfolding, it's all organic and it's basically just interacting patterns. I don't know

what consciousness is, I haven't a clue, but it came to me one time in a meditation that consciousness is the universe being aware of itself, or pattern being aware of pattern. I really don't know what that means, but we're coming back to a view that is pattern oriented.

Complexity theory is the symptom, not a cause. Complexity theory is coming out of all the sciences and all the arts. We're seeing that the world is structured in a formational view. It's a view where biology displaces physics, where Darwin displaces Newton, where the computer displaces pencil-and-paper analysis. There are many movements here, but we're coming into an organic view. Once we're in an organic view, then the separations we made — subject/object, problem/solution, and so on — don't make sense anymore.

When you do away with those distinctions, you're in a completely different set of problems for management. **The odd thing is that the more complicated and developed that technology gets, the less mechanistic it becomes, and the more organic. This is true of everything. The Internet is essentially very organic.** It builds from what's laid down already. It's not easily describable. It's not very homogenous, and it tends to reach out and just unfold.

GJ: It's impossible to control.

W. Brian Arthur: Exactly. In the so-called real world, the economy itself is becoming more and more organic, and therefore the people who operate in the economy have to take that into account. The whole zeitgeist in itself is becoming less mechanistic and more organic. In turn, we're much more conscious.

There is a continuum of problems, and some are very straight problems. Say I schedule your delivery trucks. It's a nice problem. It's well defined and so on. How you structure that will determine what happens there in the next five years. Now we're moving into an area where management becomes less about scheduling fleets of delivery trucks and more about defining this whole area. A lot of what we were talking about has to do with different layers of what cognition means. There is no simple answer to that. Cognition might simply mean rummaging around in your attic for the frameworks and then saying, "I like this one. We're really in a such and such situation." Or it could mean deep inner knowingness. I think that the East has an understanding that inner knowingness exists and that it's worth something. But, again, this is a place I am totally familiar with and you are too, but it's very hard. I've never thought about this for managers.

XI. The Business of Business Is Cognition

If you start to look at business as an entity, if the business of business is cognition rather than optimization, then you see business totally differently.

JJ: Right.

W. Brian Arthur: The more high tech a business gets, the more the business is a cognitive one. That has very different implications. For example, if I'm a New York bank and I want to get into digital banking and I know it's going to be an appendage of what we're doing now, but in ten years' time there are going to be a half-dozen large digital banking networks, then how do we do it? It won't be tough like it is now if you have to get into your bank account. You'll be able to take \$10,000 and drag and drop it into a mutual fund for the next three weeks. Now the problem is that there is layer after layer of what to do, but the first thing I'd do is what Sony does and tell you to take your very best people and immerse them.

The people who win high-tech games are the people who cognize best — I wish I had a better word than “cognize” — the people who can frame it most accurately. If you can figure out what the game is rather than how to play it — it's pretty obvious how to play it — then you're going to do well.

If you think of the game as simply an extension of what went on before, you're going to get shoved out. So if this is a very large bank, you can take a couple of senior people and send them to Seattle or California to immerse them for a couple of years. But the moment they come back they're in for a very frustrating time. Suppose they come back and you say to them, “Fine, you've got the message and you've convinced me. I'm the chairman, I'm convinced, but you know it is contrary to everything I've done in my career, the board isn't going to like it.”

In a cognitive economy, most businesses are going to be small. They will have the ability to adapt faster; they'll be more flexible. There isn't a prayer of changing the large companies, but you can immediately set up a new one. I think that's the way to move forward.

The Question

Let me put a question to you then, because I think this is an open question. You should mull this over. Every era of business has different outstanding problems. When production lines came along, the problems had to do with balancing production lines and getting people operating in an automatic way. At that point you had Taylor and people like that; you got time and motion type of management consulting and so on. In the Depression, the problem was how to shut down companies, and McKinsey was in that business. The '50s was an era when how very large companies were structured made a huge difference. Strategic planning,

a la McKinsey or Booz Allen, became very important. There might be another era now where you could say it's all about mergers and acquisitions and putting together this and that, and some people do that very well. Now, what would a consulting company look like if it were in a cognitive economy?

This is more than teaching people to learn, **it's actually sense-making**. It's not just coming in like a McKinsey and saying, "The world has changed and we want to spend several months with you figuring out how things have changed and what businesses you ought to be in." That is done by every consulting company. This would go deeper. This would say, "Business after business comes to me saying they're facing **90-degree turns**, meaning that their whole business could go in a completely different direction. Not 180 degrees, not 30 degrees, but 90 degrees, and what do we do about it?" Usually this has to do with the digitalization of industry.

My response would not be to go set up this or that, but to get your best guys and put them out there where they will absorb. **It's not what people know that counts; it's what they take for granted**. What's taken for granted around here is very different from what's taken for granted in New Jersey. You need to put them in a more useful cognitive atmosphere, where they absorb the culture and learn to see what's taken for granted.

I just want to put it as a question to you because I think that there is a business there. It's a very worthwhile and valuable one: How do you operate in an area where the main problem of management is becoming how to cognize and mentally structure a very changing environment, where the skills to be brought to bear on it are not trivial? They're rather deeply understood, if they're understood at all.

Social Embeddedness of Knowledge

As I said earlier, your friend and some friends in Japan say you could have all the deep insights in the world, but they would not know the kind of debts that would be needed to bring to bear the skills to set up companies like that. I could download the deep secrets of creating Stradivarius violins, but unless I knew where to get the wood and the glues and the people who understood all that, I could do nothing about it. This knowledge was embodied in people in the 1700s in a small town in Italy. It was not just that they understood how to build violins, but what was taken for granted about the various components. The way the wood took shape. The way it was aged. What degree of moisture you leave in it before you put the resins on it. **All of this is embodied not in just one person, but in the whole surroundings of that culture. When that starts to get lost, it's not sufficient to put it back. In that sense, cognition doesn't just stop with one person's understanding. It has a large infrastructure as to what your neighbors' cognitions are, what is taken for granted in that culture, and then**

what is physically available in that culture to work with. I think that's why regions often get ahead and stay ahead for centuries.

From that point of view, Silicon Valley is a set of cottage industries. It's a set of little Stradivarius groups. They're actually downstairs here. I can hear them, but I don't understand half of what they're saying. It's all jargon. People in Silicon Valley all know exactly what each other means, and they know where to get what they need, they know how to put it together, and so on. From that point of view, high tech is a cottage craft, and yet how to put it all together and make it work is a cognitive challenge. The Stradivaris knew what they wanted to do. They were making violins. The fathers had made violins; they streamlined and perfected the work and passed it on through their families. Violin-making was going to endure. If you made violins here, you would have to hit the market just right, and then fifteen months later it would be something else. Four months ago, the bright thing here was eBay. eBay is history now. The country is starting to find out about eBay. eBay is over. They've all made their \$200 billion or whatever. The concept is there, it's past, and then you go on to the next big thing. This whole area operates in a series of big things, but what's appropriate in each era is a different set of circumstances. So it's a very different set of cognitive challenges.

Precognition

COS: In your *Harvard Business Review* article you use the term "precognition," and you say Bill Gates would be pretty good at precognition. What kind of cognition does it take to arrive at such a precognition? Wouldn't that be the thing we talked about previously? This is, you have to access the level of knowing rather than of just conceptual knowledge? How do those relate to each other?

W. Brian Arthur: I think this has to do with conscious cognition. Having a very wide inventory of experience at an appropriate level in an industry is unbeatable. But if my inventory of experiences is in Pepsi-Cola and I'm brought in to Microsoft and then told, "Your challenge is to bring us into the Internet age," then my first question is, "What's the Internet?"

If you have a long history at that level of deep knowledge then maybe you can do what good cooks do. "Well I can combine this with that. I know this works. That tastes good, but then if I add that bit of ginger to offset that, it will be even better." If you can't cook, or you haven't used those ingredients before, you can't do it. It's that sort of knowledge.

There is a paradox, because if you are only inside the industry, you're used to what's being done already. So the idea is to be outside, to gather fresh recipes, fresh ingredients, learn new combinations, and then come back to your old position. But if you are in a pastry program and you're asked to do lamb, you're not going to get very far.

I find that most of the ways of doing digital business are 90 percent digital and 10 percent what the industry is about. For example, digital banking would be 10 percent finance and 90 percent software plus telecommunications. The people who are going to do well are going to come out of the software and telecommunications industry. They'll buy the bank. Microsoft can take over Citibank and buy it eight times over, not vice versa. The opposite notion is, I'm a New York Bank and really I want to extend my services into digital banking. I'll buy myself a few software programmers and we'll do what we're already doing, but we'll be able to do it on the Internet. That's not the way it's going to work. The way it is going to work is people who have had experience at Amazon, Microsoft, and eBay are going to get together and say "Okay, you do the encryption, you do the clearing, you do the interface, let somebody else do such and such; oh, and we need a bit of finance. I know somebody in New York who has a bank. We'll buy the bank." The bank will get absorbed and it will cease to be physical.

JJ: We feel like it has been a privilege to be with you.

W. Brian Arthur: I've been delighted. Thank you.

XII. Reflection

In this interview, W. Brian Arthur made three significant points: One, in order to understand today's world economy, we need a different theoretical foundation of economic thought. On this point, Arthur is best known for his work on the economics of "increasing returns," which suggests a much more dynamic, fluid, and unfolding view of the economy. Two, what it takes to operate in this environment is a different kind of knowledge and knowing: a knowledge that does not stem from an abstract framework that we apply to or impose on a situation, but a knowing that emerges from the quietness of a deeper place. And three, what it takes to access this deeper source of knowing is to follow three steps: (1) total immersion: observe, observe, observe; (2) retreat and reflect: allow the inner knowing to emerge; (3) act in an instant: bring forth the new as it desires.

XIII. Bio

W. Brian Arthur is Citibank Professor at the Santa Fe Institute. From 1983 to 1996 he was Dean and Virginia Morrison Professor of Economics and Population Studies at Stanford University. He holds a Ph.D. from Berkeley in Operations Research, and has other degrees in economics, engineering and mathematics.

Arthur is best known for his work on positive feedbacks or increasing returns in the economy—what happens when products that gain market share find it easier to

gain further market share—and their role in locking markets in to the domination of one or two players. His work on increasing returns won him a Guggenheim Fellowship in 1987 and the Schumpeter Prize in Economics in 1990. It also won acceptance in Silicon Valley, where strategies based on increasing returns ideas now dominate high tech thinking. And it became the basis of the US Dept. of Justice vs. Microsoft case of the late 1990s. His papers on this topic were published in *Increasing Returns and Path Dependence in the Economy*, U. Mich. Press, 1994.

Arthur is also one of the pioneers of the new science of complexity—roughly speaking, the science of how patterns and structures self-organize from simple elements. His work here is detailed in Mitchell Waldrop's 1992 book *Complexity*. His current interests are the economics of high technology; the "digital economy"; how business evolves in an era of high technology; and cognition in the economy. He is writing a book on high technology and the different economy it is bringing into being.

Arthur was the first director of the Economics Program at the Santa Fe Institute in New Mexico; and he currently serves on the Board of the Institute.