Odyssey

Pepsi to Apple . . .
A Journey of Adventure, Ideas, and the Future

JOHN SCULLEY
with John A. Byrne

1817

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A Telephone Call

The calls came frequently enough. As president of Pepsi-Cola, I ot a lot of them from headhunters of all kinds. I had won an enviable nd visible place for myself in the corporate world. I was on the over of *Business Week* magazine in ~~May~~ June 1973, at the age of thirty- our. I was frequently quoted in the business columns of newspapers nd magazines. And I was having fun running what then was Pepsi- o's largest single business. Oftentimes, I wouldn't even return the alls. I had absolutely no interest in leaving Pepsi.

Only one headhunter could attract my attention. He was Gerry oche, chairman of Heidrick & Struggles, Inc., in New York. A charm- ng, gregarious man, Roche is the ultimate CEO power broker, a eadhunter extraordinaire. He has recruited more chief executives nd presidents to major U.S. corporations, from CBS to RCA, than ny other executive recruiter. Gerry had spent nearly two decades f his fifty years networking his way into the boardrooms of the ountry's top corporations.

When Gerry called, there was a big difference. I knew he dealt nly with the top jobs, and that if he was spending his own time on omething, it was important. You would not fail to return a call from erry Roche.

I had known him as a headhunter and friend for years. In early 977, he tried to interest me in the presidency of Norton Simon, nc., the cosmetics company. Roche later tried again with the chair- anship of NBC, and more recently earlier in 1982 as chief execu- ve of Warner-Amex, the cable television venture of Warner ommunications and American Express.

I had no interest in any of those jobs. Pepsi was my life. I threw so much intensity into my work that I seldom looked up to ask if this was what I really wanted out of a career. My allegiance to Kendall and his company ran deep; I made the company my extended family. The mere thought of entertaining another job would have provoked the angst of a personal separation or divorce.

Gerry, however, is an engaging personality, a corporate storyteller who can effortlessly entertain someone for hours, and we developed a good friendship over the years. Gerry occasionally would check to see how my career and life were progressing. So when he called me at Pepsi two days before the Thanksgiving Day recess in 1982, I assumed it was another friendly check-in call. After exchanging pleasantries, however, he quickly got down to business.

"John," he said, "you and I have known each other a long time. I know that you're untouchable and not interested in outside jobs. And you know I wouldn't call unless it was something that was very important. But there is something which I think you've got to let me tell you about and hear me out."

Roche told me he was searching for a chief executive for Apple Computer, Inc., in Silicon Valley. I didn't know very much about the company. I had purchased one of their computers, an Apple II Plus, for my office, and was experimenting with setting up an information network among bottlers so we could share sales and promotion information. I was hardly interested in the job, however, and told him so.

"I know you don't want to leave Pepsi, and I hate to ask a favor of you," he said. "But please trust me. Would you make a trip to California and at least meet these guys?"

"Gerry," I said, "let me think about it."

Shortly after our conversation, Gerry dispatched a package of information on Apple by messenger to my home. That evening, a manila envelope from Heidrick & Struggles lay atop my stack of mail. I didn't open it at first. I brought it into my library, where I often would go at night to build a fire, listen to classical music, and read. I shuffled it to the bottom of a pile of reading material—a new *Yankee* magazine, other correspondence, and memos from a day's work at Pepsi.

I didn't open it until after dinner. Inside was a copy of the company's latest annual report and a ten-month-old *Time* magazine.

On the cover was a boyish-looking Steve Jobs with an arrow-shaped laser beam splitting a red apple balanced atop his head. The story, on "America's Risk Takers," gushed at how the mustachioed Jobs had practically created the personal computer industry single-handedly. It told an amazing tale of a passionate folk hero whose enduring dream was to allow individuals the power that only large corporations and institutions were able to wield. He accomplished this by personalizing the computer, once a distant, nearly ominous abstraction in the form of large mainframes, and bringing it down to scale so it could rest on a person's desktop.

Six years earlier, Apple was a company located in the bedroom and garage of his parents' home in Los Altos, California. Now it was a Fortune 500 company. Yet Jobs hardly played the part of a Fortune executive. A slender figure with long sideburns, he wore frayed jeans and cowboy shirts to our pin-striped suits. He had the appearance of a college student.

A child of the Valley and its dreams, he became intrigued by technology as a student at Homestead High School in Los Altos. At night, he would attend lectures at Hewlett-Packard, the Valley's huge electronics company. To the amazement of his high school electronics teacher, Jobs boldly called William Hewlett one day to ask for parts and equipment for his projects.

A college dropout, Jobs landed a job designing video games at Atari in 1972. After work, he would visit the Homebrew Computer Club, a haven for electronic hobbyists and computer hackers. It was there that he met Steve Wozniak, a self-taught engineer at Hewlett-Packard. "Woz," as he was known, and Jobs became friends and pranksters. They built and sold blue boxes that allowed users to illegally make long-distance telephone calls for free.

Wozniak was the computer wizard. He was working hard to construct a small, easy-to-use computer that he would bring to the group's meetings to show fellow computer buffs. He had little interest in its commercial appeal. Jobs, however, immediately saw its potential and convinced Wozniak, who later quit his job at Hewlett-Packard, to make the hobby a business. Jobs sold his Volkswagen van, while Wozniak parted with his Hewlett-Packard scientific calculator. The pair raised $1,300 and opened a makeshift production line in a garage, producing the computers in kit form for electronic hobbyists.

It was A. C. "Mike" Markkula, a former marketing manager for Intel, who would provide the needed business expertise behind the unique partnership. Steve discovered him through a venture capitalist recommended by Atari founder Nolan Bushnell. Markkula had retired only a year earlier at the age of thirty-three after stints with Fairchild and Intel, two of the most successful computer chip makers in the country. A dedicated family man, he envisioned a leisurely life on his Intel stock options which brought him multimillionaire status.

That was until Jobs persuaded him to visit his garage. Fascinated by what he saw there, Markkula began to help the two formulate a business plan, arrange a Bank of America credit line, and talk a couple of venture-capital firms to invest in Apple. Within a few months, Markkula put in $91,000 of his own money, and joined the company as its de facto chief executive.

The formal company's first product, shipped in 1977, was a redesigned prototype in a light, attractive plastic case, dubbed the Apple II. The company went public in December 1980. The annual report, only Apple's second as a public company, charted its extraordinary performance since then. Apple already boasted the largest installed base of any computer company in the world. Net income: up 56 percent to $61.3 million in the year ended September 24, 1982. Sales: up 74 percent to $583.1 million.

Beyond the numbers, the document impressed me with its elegant simplicity. Its cover featured a twenty-year-old quotation from President John F. Kennedy, "Man is still the most extraordinary computer of all." Inside, the report explained that Apple's technologies and products are created by those most extraordinary computers: its employees. Some of them were captured in stark black-and-white pictures that suggested they were far from typical employees. Rather, they were intense individuals on a dramatic mission.

Jobs and Markkula were pictured together, striding down a corridor at a quick pace, their shadows on the floor behind them. A gesturing Jobs in a white shirt and tie seemed to be lecturing, while an attentive Markkula, in a tweed sports jacket and baggy trousers, walked along at his side, hands in his pockets. The caption, written in script beneath the photograph, aptly described the mission: "Bringing technology to individuals through personal computers is, we believe, the extraordinary business of this decade."

It piqued my interest, if only because I didn't know much about

"Hi," he said, when he emerged, "I'm Steve Jobs. It's really great you came out here. I'm really happy to meet you."

We walked to Anthony's Pier One restaurant, a few blocks away on the edge of the Apple campus.

"Look," I told them, "I want you to know I'm not really here for a job interview."

"We understand," said Mike. "We're excited about the chance to meet you and understand your marketing ideas."

Steve ordered a vegetarian dish, a salad of some kind. Over my filet of sole, I began to run through many of the same things I had just covered with Mike. Steve barely said a handful of words during the first half hour. He sat and listened, his sharp, brown eyes intently fixed on me in a commanding stare.

It wasn't until I began speaking about how I hoped to use the Apple II Plus Computer to communicate with Pepsi bottlers that he perked up. "We're going to make it even better," he said. "We've got some incredible ideas that will revolutionize the way people use computers. Apple is going to be the most important computer company in the world, far more important than IBM."

It was characteristic of Steve to speak in both vivid and sweeping language. "What we want to do," he explained, "is to change the way people use computers in the world." Steve launched into an explanation about how personal computers were going to change the workplace forever, maintaining that Apple had secured the lead role in this transformation because it understood the future better than any other company. It was started by people who loved the products they were building. "I can't talk about it," he said, "but we're going to be doing something that is really going to blow everybody's mind with a neat new product."

The new computer, called the Lisa, would be introduced by Apple at its shareholders' meeting in one month. Unlike the Apple II, the Volkswagen of computers, it was expressly made for the Fortune 1000 market. The advent of a software program called VisiCalc brought the electronic spreadsheet to Apple II and allowed its use by business. But IBM had been making considerable inroads in the corporate market since the 1981 introduction of its personal computer, known simply as the IBM PC.

"I don't know much about computers," I confessed, "but I can

tell you the kind of things that I think business people want to be able to do with them."

We talked about how computers had to become more functional, and I explained some of the things I could and couldn't do with the Apple II Plus. At Pepsi, I found the Apple to be more work to use than it was worth. We tried monitoring our mail and phone calls and discovered it wasn't worth the time. We tried typing letters on it, but couldn't get a letter-quality printer then. We also began to talk about marketing, which Steve said he knew little about.

"I'd be really interested to come back and visit you sometime and learn more about marketing," he said. "I really like New York and, in fact, I'm even thinking of getting an apartment there. Maybe we can get together sometime in New York."

"That would be great," I responded.

At the end of the luncheon, we walked back, I got in my car and headed for the airport that afternoon. It was a brief meeting, but it left an instant impression. I thought Apple was different from anything I had ever seen before. On the flight, I took out a piece of hotel stationery I had saved and began to write a letter, outlining my concepts of what a personal computer should be able to do.

I informed Mike I was canceling my plans to replace my Apple II Plus with an IBM PC, at least until Apple announced its newest computer on January 19. All this was a unique and foreign vocabulary for me. Yet I knew I could somehow make a contribution. So I jotted down a collection of thoughts and reflections about some of the things we had discussed. The result was an eight-page letter, filled with underlined phrases and words, diagrams, cubes, and boxes of conceptual models and decision-making tools. From my own experience at Pepsi, I had found that the hierarchy of an organization would work against the microcomputer's entry into corporate America. Steve told me Apple was about to introduce a personal computer expressly for the corporate world.

Corporate management information systems (MIS) managers then had little understanding of or experience with personal computers. When I asked Pepsi's MIS department for their evaluation of the Apple II Plus and IBM PC, they told me about the computers' hardware and software features, but could not articulate what I could do with a powerful personal computer.

"To reach upper management," I wrote, "you need to promise *decision power,* not features. Upper management needs to see the opportunity for micros to *coexist* with mainframes and minis. As big a breakthrough as VisiCalc is, upper management doesn't do much spreadsheet analysis . . . and is already pressed for time. So using a personal computer will be looked at as *adding* more work on a crowded schedule; the time/cost vs. benefit must be rewarding."

To get the personal computer into the executive suite, I felt it had to be useful in strategic planning, a primary task of upper management. Ideally, it should link a company's large database with the conceptual models top management employed in strategic planning. The personal computer, I thought, should produce documents that combined text and visual models.

"Spreadsheets, pie charts, and bar charts don't have much sex appeal for this group," I advised. "Build structural visual models that can be animated on screen . . . make it possible to rotate a cube, slice it, explode and rotate out a building block and reformat data into other matrix designs. If you could do this and give upper management a way to manipulate data and options within the models, I think you could really have something great!"

Given my paucity of knowledge about computers, I had no idea if any of this was possible. What I did know was how to market to consumers. So I told Mike and Steve not to stop with hardware and software innovation, but to also work hard to merchandise the company's technology.

Invest in in-store merchandising that *romances* the consumer with Apple's potential to *enrich their life!* Here's where I think both IBM's PC and Tandy's TRS-80 are vulnerable. It will be hard for IBM to ever forget they are in the data processing business offering a range of systems/services, or for Tandy to separate itself from the "do-it-yourselfers" who are looking for the latest affordable gadgets.

You have a unique opportunity to differentiate Apple from the others, so don't miss it. Use bold animated color graphics and VCR instruction modules which will give consumers an exciting experience when they try an Apple at your display. Make your merchandising as "turnkey" as possible, letting the computer and its associated technology *do its own selling.* This is an expensive and important project *deserving of as much creativity as any of your major new products.*

It was the same approach I had taken during my years at Pepsi,

treating packaging and merchandising concepts as if they were new brands. "I really enjoyed meeting you both and want to thank you for an exciting day," I concluded. "What you have already done is impressive, but your vision for Apple's future is even bolder and really captures my imagination." I was careful, though, not to suggest I felt like a candidate. If I saw Steve again in New York, it wouldn't be as a candidate for a job but as a casual acquaintance. I had no interest in giving up my career at Pepsi, but I was taken with this young, impetuous genius and thought it would be fun to get to know him a little better.

Leezy and I had just driven up to our home in Camden, Maine, for the Christmas holiday. I had been there only a few minutes when I received a call from Gerry Roche. It was one of what soon would be many such calls.

"How did you like the trip to Apple?" he asked.

"It was really interesting," I said. "I enjoyed meeting those guys. It was totally different than what I expected. I really didn't get to see an awful lot, but I particularly enjoyed meeting Markkula and Jobs."

"Well," Gerry said, "they enjoyed meeting you. These guys are very excited about their meeting with you. John, I know you're not interested in this, but you really owe it to yourself to meet with them again."

"Gerry," I explained, "the understanding was that I would just go out and look at it, and I told you I'm not looking for a job. I don't think I want to get more involved with this. This is only going to cause me more problems later on, so I would just as soon end it now."

Gerry, whose persistence has been known to wear down the resistance of many executives, refused to take no for an answer. He asked me, instead, to think about it for another day. Within twenty-four hours, the phone again rang with Gerry on the other end. He apparently spoke with Steve during the interim.

"Steve Jobs told me that he's coming to town after Christmas," Gerry said, "and he would love to get together with you for just a few minutes. So you don't have to go anywhere. All you have to do is meet him, and he'll meet you anywhere you want."

"Well, that's okay. I guess if I don't have to go to California, I'll go and meet him. I did say I'd get together with him sometime when he came to New York."

We scheduled an after-work meeting for January 12. The plan was for me to meet Steve at the Carlyle Hotel in New York. It was a cold night, with snow on the ground. When I introduced myself to the concierge at the Carlyle, he told me I was expected. I took the elevator to the twenty-first floor and walked down the hall to Steve's room. The door was ajar and I could hear excited voices inside.

My knock brought a young woman to the door, part of Steve's Apple entourage. When the door opened, I could see a group of young people, all in their twenties, surrounding a computer with a lit display. Steve emerged from them in a loosened tie and rolled-up shirtsleeves. The group was at the end of a long and tiring day.

"We've had sneaks all day," Steve said.

"What are sneaks?" I asked, mystified.

Steve explained that a sneak is a preview of a new product on a confidential basis to a member of the press. Apple was showing off its newest product, the Lisa, to selected writers from *Time, Business Week, Fortune,* and other major magazines and newspapers. The Lisa was the product Steve wouldn't mention to me over lunch a few weeks earlier. It was Apple's first attempt to crack the all-important business market. At $10,000 a machine, Lisa was Apple's most expensive computer yet. But it also was a highly advanced and surprisingly easy-to-use machine.

"Boy, it has gone fantastic," said Steve. "Everyone loves the new product. It is really incredible. I want to show this to you."

He introduced me to his associates as the president of Pepsi-Cola. He told them he was giving me a "sneak" because Pepsi might be interested in being one of the first major corporations to get behind the Lisa.

John Couch, a medium-built man with a small mustache and slightly drooping eyes, demonstrated the computer. The Lisa division's general manager, Couch explained how a small hand-held device, called a mouse, controlled a pointer on the computer screen. When you rolled the mouse over a desktop, the pointer moved across the screen, allowing you to point to graphic symbols or instructions. Just a click of a button on the mouse controlled the computer's functions. The mouse vastly simplified the computer's operation, allowing people to learn how to use the Lisa in only one sixtieth the time it took to grasp other personal computers.

"Why don't you try it?" Couch said.

I sat down, created a few parallelograms on a program called LisaDraw, and made a cube of it. Then he showed me how to merge the graphic with text on the same screen. An Imagewriter printer spat out my creation within seconds.

Every time Couch explained something, Steve would interrupt. Couch spoke about what the computer did, while Steve always talked about how it would revolutionize life and work. Steve's comments were as irrepressible and impetuous as Couch's explanations seemed temperate.

"We're going to blow IBM away," Steve boasted. "There's nothing they can do when this computer comes out. This is so revolutionary, it's incredible."

I sensed a rivalry between the pair. Couch, a former Hewlett-Packard engineer and another of Apple's multimillionaires, had been given the job of running the Lisa division in 1980 when Steve wanted it himself. Markkula and then-president Michael Scott, however, thought Steve lacked the experience to hold an important operating position. A disappointed Steve Jobs went off to take charge of a much smaller technical project that was developing a computer under the code name Macintosh. Steve bet Couch $5,000 that his group would ship Macintosh before Lisa. Steve, of course, lost the bet and had to pay up later that spring.

At the same time, there was another fellow in the background named Paul Dali, one of the co-general managers of Apple's personal computer systems division which produced the Apple II products. Dali kept trying to explain how his group was introducing the Apple IIe, an enhanced version of the Apple II Plus in my office. But everyone seemed far more interested in the Lisa product.

Steve suggested that the four of us go to the Four Seasons restaurant for dinner. The maitre d' sat us at a corner table, arranged for a vegetarian meal for Steve, and took our orders. I talked about the origins of the Pepsi Generation campaign and its impact on marketing, how we articulated to a new generation of young people a new lifestyle, and how Pepsi became part of that. I explained how it became a phenomenon, almost a cultural dimension of American society, a campaign that was able to survive longer hairstyles, protests in the streets, riots on college campuses, all of the country's turbulent changes of the sixties and early seventies.

The campaign succeeded because it focused on the world's

consistency in implementation throughout the corporation. These are the traditional strengths of second-wave companies. But the world of today is not the same as the world of the mid-twentieth century, when these companies' business styles were refined. Volatility and interdependency are concerns second-wave companies were not built to handle; success may prove more elusive for companies which fail to transform themselves.

What the second-wave model often lacks are the ingredients that will determine success in the information age: flexibility, creativity, and innovation. All are hampered because each level of the hierarchy in a second-wave company is a filter. Every level has the right to say no, but seldom does it also have the right to say yes. If good ideas percolate to the top of the organization, they do so slowly. That means new products and new emerging markets aren't quickly seen in a second-wave company. That was acceptable when time wasn't a factor. But few of us have the luxury of time anymore.

Lots of high-tech companies are in the third wave. That's because technology allows things to be done better and cheaper than before, and because high-tech companies are attractive to people who aren't burdened by the experience of traditional management. But not all third-wave companies are in this sector. Chapparral Steel is an example of a company in an archaic business that has nevertheless successfully made the leap and is doing quite well as a result.

Flexibility

At Chapparral, people hold flexible cross-functional jobs so that the vice president of administration has actually doubled as a switchboard operator. The organization is flat, lean, and flexible. Growth by vertical integration is viewed with disdain, and the factory is considered a true laboratory for experimentation. Employee productivity is almost four times that of the average U.S. steelworker and nearly twice as much as the Japanese.

There are also "flexible walls" at Apple. People like the idea of working in open spaces with cubicle partitions that can be assem-

Contrasting Management Paradigms*

Characteristic	Second Wave	Third Wave
Organization	Hierarchy	Network
Output	Market share	Market creation
Focus	Institution	Individual
Style	Structured	Flexible
Source of strength	Stability	Change
Structure	Self-sufficiency	Interdependencies
Culture	Tradition	Genetic code +
Mission	Goals/strategic plans	Identity/directions/values
Leadership	Dogmatic	Inspirational
Quality	Affordable best	No compromise
Expectations	Security	Personal growth
Status	Title and rank	Making a difference
Resource	Cash	Information
Advantage	Better sameness	Meaningful differences
Motivation	To complete	To build

* Inspired by James E. Cook, technologist, entrepreneur and former technology vice president of Computervision Corporation.

+ See tutorial on "Living Out the Genetic Code" on page 318.

bled and reassembled over a weekend. In most cases, we lease facilities. The culture doesn't put a premium on what one's office looks like. It gives us immense flexibility to reorganize.

Reorganizations, in fact, are looked at positively. In many corporations, they're viewed with anxiety. People wonder, "Where do I go, what will I do?" That's especially true in companies that have had no layoff or have cradle-to-grave employment policies. In Apple, it's constant change. People expect buildings, structures, offices, and people to change. Organizations shouldn't have permanence.

The Network Organization

For the first time, alumni of the sixties generation and the Vietnam experience are moving into the ranks of business leadership. They are loosening the bonds of leadership from a hierarchical to a network model.

The beauty of a network is that it has no center. It is a process more than a structure, composed of modular groups that establish themselves to take on specific tasks—not to build fiefdoms as traditional "departments" do. Depending on the situation, the leader can thus also be a follower and a peer, offering inspiration, not his own dogmatic views. Often I am a leader in one network but a follower in another, as I take a back seat to players who are stronger in product development or manufacturing. The corporate leader is not necessarily a paragon of wisdom: in most second-wave companies he is the end product of a process of elimination, not a process of cultivation where talent and ideas shine.

How then can the third-wave leader add value? He still sets the agenda—he says, Here's what's going to be important for us, and thus decides where the resources will go. His job is to empower the network. In a second-wave company, by contrast, the network is an informal one and is simply tolerated.

Why is the network so important? Because that is the natural course of how ideas flow. Third-wave companies are designed for management by dissent. Second-wave companies are built to foster consent, which is considered healthy. Apple would never develop the products or principles it has if not for the love for colliding ideas.

Structure has no permanence. Third-wave companies are not necessarily centralized or decentralized. There are times when you want to change structures; the network shifts to accommodate the change. Our network is made up of temporary teams that are formed and then disbanded as events necessitate.

The network also calls for fewer employees. Consider Digital Equipment Corp. (DEC), one of the real computer success stories in recent years. It had $6.5 billion in revenues and 89,000 employees in 1985. Apple, on the other hand, racks up more than $2 billion in annual revenues with little more than 5,000 employees. If

we were to grow three and one-half times DEC's size and increase our workforce by the same rate, Apple would have all of 17,000 employees versus 89,000 at DEC.

We're able to keep so lean because we rely on an independent network of third-party business partners—independent software developers, makers of peripheral equipment, dealers, and retailers. We provide a conduit for creativity and innovation. The true entrepreneurs, then, are those who take advantage of the network.

Some critics wrongly assert that such arrangements have led to the emergence of the "hollow corporation," a vulnerable shell whose survival is dependent on outside companies. When you look behind these seemingly large entities, they contend, you discover a facade—no manufacturing, no sales channels, very little other than services.

The critics have misjudged the vast advantages that accrue to such organizations. When Apple fell into its crisis in 1985, our dependence on this network of outside companies significantly heightened the pressure on us. If they abandoned Apple, our future would have been less than secure. But the flexibility we gained from it far outweighed the disadvantage. If we had greater numbers of people, as DEC does, if we owned our buildings, if we were more vertically integrated, we would have faced an even greater and more painful crisis. There is a great source of strength in having a corporation with few people.

For every dollar of revenue in the catalyst company, the external infrastructure may generate three to four additional dollars of sales. Vertical integration, therefore, assumes less importance, and corporate size becomes less significant. Of far greater import is the enhanced flexibility to turn change and chaos into opportunity. Our network helped us turn desktop publishing into a marketing phenomenon by providing the software and peripherals.

Motivation

Second-wave companies are in the business of getting bigger. Size is their religion. Third-wave companies are more interested in finding a better way.

This leads to a primary third-wave goal: to make yourself and your own products obsolete. No one should be more competent at that than you. Our Macintosh replaced the Lisa, Apple IIgs was designed to replace the earlier Apple IIs. What we do is find ways to give people a growth path—upgrade—to the next product, to the future, not abandon customers who have bought the now-obsolete product. The way we renew ourselves is to supply our customers with meaningful differences. In second-wave companies, the product objective is generally meant to give customers better sameness—an improved version of their same old product.

This is a very contrarian idea. Second-wave companies do everything they can to defend what is already theirs. They will spend more and more money to do so or acquire a company to control the competition.

Individual vs. Institution

At Apple, we take this conflict for granted while most second-wave companies ignore its existence. We exist for our people, who are our lifeblood, not the other way around.

Second-wave people are motivated by promotion, salary, and bonuses. Third-wave people are motivated by commitment to an ideology, by the chance to personally change the world, the chance to grow as a person. The second-wave company does not offer this as a possibility, not in the promise of lifetime employment and the lure of a pension. As a result, third-wave people are more likely to take risks, to court failure. They are playing according to a different standard—their own, not the company's. Their attitudes are based on the possible rather than the actual. They must, as a result, be given high rewards for their high risk, especially in stock options.

Quality

In this new wave, quality takes on a broader definition. It doesn't apply only to the product; instead, quality is pervasive throughout every part of the organization. Quality, without com-

promise, is expected in every function and every department, from finance to sales. It's everyone's job. And it's defined by anyone who wants to compete—not just who is bigger and has more clout.

That's one of the reasons why so many American companies fell into trouble. They measured quality in terms of what was affordable, meaning what level of predictable error was acceptable, rather than insisting upon perfection at the start. The proof of this is in some of the gains traditional corporations have registered in quality since the early 1980s; the increases are shocking not for their improvement but because they reveal how bad things actually had gotten.

So what does all this mean? The differences between second- and third-wave companies require vast revolutions in attitude and behavior. These differences are worth noting during the time of transition we are in currently. The third wave is a model we would do well to begin implementing.

The Geography of Learning

Sometime in the late 1990s, the newspapers are likely to run headlines of two events that may well change the course of our nation. By then, the Soviets will have landed the world's first manned mission on Mars, creating a second "Sputnik effect" of fear that our kids aren't learning to the degree they must. And at that moment, we'll discover that up to 35 percent of our teachers have retired—and nobody will be on hand to teach our kids.

In 1957, the Soviets launched Sputnik 1 into outer space, startling the world and shocking the United States. It took just such an amazing surprise to galvanize the nation to action, creating NASA and committing hundreds of millions of dollars to technical research.

Now the average age of our teacher is the late forties, and fewer people are entering the teaching profession than in any period in recent history. Women, for years the richest resource for the teaching profession, are pursuing different careers. And unfortunately, our society has turned teaching jobs into low-esteem, badly paying work. Many of our teachers, their morale incredibly impoverished, have been reduced to becoming babysitters in large urban schools.

These two unrelated events may spark a general reawakening not only that America has lost its presumed technical edge in the world, but that our only solution out of the crisis lies with the youth of the country, a generation likely to be denied the needed

numbers of teachers to bring it along. But maybe this won't be so bad.

As a nation, we seem able only to respond to a crisis. The problem is we have one now in learning that we have yet to acknowledge fully. Some 23 million American adults are functionally illiterate. About 13 percent of our teenagers can't read. From 1963 to 1980, a virtually unbroken decline took place in average scholastic test scores. When compared with students from nineteen other industrialized nations, U.S. students ranked in last place seven times, and never have we achieved first or second.

The personal computer isn't the panacea for this problem, but it is a tool around which solutions can be sought. This is really how computers will change the world, by changing the children who in turn will alter our perspectives of the world. Computers certainly will have a deeper impact on children than they ever will have on the linear, book-fed people of my generation. The personal computer provides us with a better "book," one which is active (like the child) rather than passive. Future generations of the personal computer will offer the attention-grabbing powers of TV, but be controllable by the child rather than the networks.

"It can be like a piano," Alan Kay notes. "A product of technology, yes, but one which can be a tool, a toy, a medium of expression, a source of unending pleasure and delight . . . and, as with most gadgets in unenlightened hands, a terrible drudge!"

The personal computer's promise has been far from fulfilled. Most of the computers on school desks today are used for simple drills and rote learning. We're still preparing our children for the same old repetitive jobs in the industrial age—the very jobs that are disappearing daily. Instead, we should be preparing them for the jobs of the future, jobs that will require thinking skills, not rote memorization and repetition.

Computers, with their library of knowledge at students' fingertips, will make it possible for children to enjoy learning by making them explorers, active participants in educational adventures. But we can't just parachute computers into the schools to do simple drill and practice routines, as Sherry Turkle has pointed out. We have to build computers into the core curriculum.

The Carnegie Foundation has been quick to notice part of the potential:

> The [new] technologies should make it possible to relieve teachers of much of the burden of imparting information to students, thereby freeing them for coaching, diagnosing learning difficulties, developing students' creative and problem-solving capacities and participating in school management. The substantial productivity advances that can be expected from computer use will result not from replacing teachers with machines, but through greatly improved achievement by students when good teachers are augmented by properly used technology.

For years the Apple II has been the workhorse in schools across America. Enthusiasts have had a long love affair with this wonderful machine. When we decided to add the Apple IIGS to our Apple II product line, we did it with the belief that we have only begun to tap the potential of personal computers in education.

Wouldn't it be fantastic if we could build an Apple II compatible that had the ease of use of the Macintosh and could also share its data files? When the engineers began this task, it seemed almost impossibly difficult, but once again they surpassed themselves. What makes the IIGS so great is its superb color graphics and stereo sound, two important features for the new age of CD-ROM optical media. Bill Gates has said that optical media will be the technology behind the next big revolution in personal computing. I agree with him. Nowhere will this be more important than in public education. It's one of the reasons why National Geographic, Lucas Films, and Apple have joined forces to work together on educational products for the schools.

Some of the most interesting work in learning today is occurring at MIT's Center for Arts and Media. The Center's experiments with mixed media, combining text windows, full-motion TV-quality video windows, and speech as part of interactive learning tools, have astounded researchers. Children, contrary to what their parents believe, can listen to U–2 on the radio and watch *Miami Vice* on television with an opened book on the floor, doing their mathematics homework. Rather than being distracted by the bombardment of media, they find that the "mixed messages" have the potential to help them learn.

If individuals can simultaneously get relevant information in a

choice of media, they will become far more effective learners. That's the capability MIT is trying to discover a technological way to harness. We've come a long way from the days when Henry James criticized Balzac for presenting "too many facts . . . ideas and images." Balzac, he groused, "becomes obscure from his very habit of striking too many matches," distracting readers by quantity and intensity. To the computer generation, both of these are pluses.

Why, after all, should we all learn exactly the same way? Every individual learns differently—by reading, by looking at pictures, or by listening. Personal computers of the 1990s will be able to customize the learning process to best fit the specific needs of the individual. Some are intimidated by the math on a basic proficiency test, yet they can mentally add and subtract numbers in a supermarket looking for the best deal. When we can put even apparently difficult information into an interesting, unintimidating context, it's not so threatening. This is exactly where personal computing is headed in the 1990s. The MIT experiments will help us design personal computers that will work better with children who can do several things at one time than with us.

On the West Coast, meanwhile, Apple is sponsoring some of the most interesting research on how to integrate computers into the curriculum. It's all going on in an old, run-down building in Los Angeles with an asphalt jungle–like playground in the back—yet this is one of the most innovative schools in the world, a very special version of L.A.'s Open Magnet Schools. The computer project, called Vivarium, is headed up by Alan Kay, who is looking for ways in which artificial intelligence, computer graphics, user interface, and curriculum design can be altered to allow people to learn better.

The children, first- through sixth-graders, will interactively design animal and plant ecologies to test, sharpen, and enrich their understanding of what they have learned. The big question is what would it be like for novice users to be able to create their own computer agents, semi-intelligent processes that could carry out tasks, find resources, advise, and coach their users.

Alan is beginning a process whereby children will be able to create their own computer agents in artificial intelligence—processes that can perform functions normally associated with human

intelligence such as learning, adapting, reasoning, and automatic self-correction. The children are now learning to design their own dinosaur-like creatures. Currently they are using Macintoshes and even low-technology tools like paper, crayons, and scissors. But eventually they will have the help of an extremely powerful computer. Kay has thus taken a difficult technical issue and turned it into a major project around which some of the world's most intelligent artists, engineers, and computer scientists have gravitated: Muppet designer Jim Henson; Paul MacCready, inventor of the novel flying machine, the "Gossamer Condor"; and Marvin Minsky, one of the true pioneers in artificial intelligence, are just three of the people already involved.

Why set kids loose on the project? The breakthroughs in personal computing Alan originally achieved were through fifth- and sixth-graders at Xerox PARC, experiments which led to many of the Macintosh's user-interface features. Kids' minds are fresh. They are more adaptable to the new technology and more likely to come up with new ways to use the system unencumbered by biases of experience, of doing things in old ways.

The experiments will help us in our lifelong learning—another education issue that will grow in importance, as skill renewal becomes essential in training people for the four or five careers they will have. In the future, the people who fail to learn may find themselves excluded from the country's affluent middle class. The notion of a middle class based largely on economics might change to one that is rooted in information and knowledge.

Unfortunately, it may take a crisis to stir us to action. But if it does, education can emerge as the new frontier, just as in the first half of this century science was the arena for discovery and enlightenment. Innovation will require not only education reform but a reformation of our concepts of learning, working, and management. Making the experience of learning self-engaging, creating an environment for learning that is fun, and providing personal tools to make technology as transparent as possible are all necessary steps.

The real computer revolution will take place years from now, with our children's generation, not our own. Around fifty years after the millionth Model T rolled off the assembly line in 1919, Jack Kerouac published his beat novel, *On the Road.* Though cars had

been around for fifty years, Kerouac's was the first generation to internalize the car's power, and he wrote vividly about the need for spontaneity and rush, according to scholar Frederick Karl. The car changed from being a "thing" to being part of the Beat Generation's soul. It meant life and escape to Kerouac; so probably will the personal computer to this new generation of kids.

tion technology not on the institutions themselves but on the individuals inside the institutions. We should be trying not to make institutions work faster, but to help people discover imaginative new ways to work better. It's not such an outrageous idea in a third-wave corporation for people to find their work experience exciting, interesting, and actually have fun!

Second, we can feel the effects of institutional dominance in the rise of overspecialization, in our universities and in our businesses. Years ago, most medical students strived to become doctors of medicine. Now they become specialists. While we have successfully enhanced the depth of knowledge in specific fields, we also have lost the opportunity to draw contrasts and comparisons between knowledge from field to field. Specialization has worked to narrow our perspectives and options. It encourages mechanistic and linear thinking.

If you believe, as I do, that point of view is one of the sources of new ideas and creativity, then specialization only narrows the vision of the individual. It doesn't broaden it, allowing the mind to explore new and vastly different horizons.

Third, time compression has nearly crippled our ability to cope with change. Technology has made the world a smaller, faster place that penalizes the slow-moving and stable institution. Companies that can quickly get ideas and information through their organizations for discussion and action will have distinct competitive advantages over others. In the next century, the world will become even more compact as computers permit real-time language translations. The lifting of the language barrier is likely to have as revolutionary a change on making the world a smaller, faster place to live as the airplane or the satellite.

Unfortunately it is unlikely we will be able to preserve our affluent middle class through gradual evolutionary steps of improvement in our businesses. Yet revolutions only occur in a democracy when there is sufficient discomfort or crisis so that enough people demand a change. And peaceful revolutions are only successful in a democracy when the proposed alternatives are obviously better than what it had previously. By the twenty-first century, we may well suffer a crisis in business and in education that will be intolerable enough to support vast changes in our society.

If these problems—institutional stranglehold, dominance of overspecialization, and rapid change—are to become the trigger points for a new renaissance, then what's missing today is the positive catalytic force. Society needs a breakthrough tool equivalent in our age to what the printing press was for the first Renaissance. A tool which will help stimulate individual creativity by awakening our minds to new points of view and giving us access to more knowledge than any human could possibly discover by any other means.

The odyssey ahead is to assure that we create the ancestor of a tool that might well be crucial to us in the next century. This is the context in which our dream to change the world with personal computers like the Apple II and the Macintosh is so compelling. It's why we view our role as artists and impresarios. It's why we wear with pride T-shirts emblazoned with slogans championing the passion and the romance of our journey.

A future-generation Macintosh, which we should have early in the twenty-first century, might well be a wonderful fantasy machine called the Knowledge Navigator, a discoverer of worlds, a tool as galvanizing as the printing press. Individuals could use it to drive through libraries, museums, databases, or institutional archives. This tool wouldn't just take you to the doorstep of these great resources as sophisticated computers do now; it would invite you deep inside its secrets, interpreting and explaining—converting vast quantities of information into personalized and understandable knowledge.

Imagine the Knowledge Navigator having two navigational joysticks on each side, like a pilot's controls, allowing you to steer through various windows and menus opening galleries, stacks, and more. You might even be set free from the keyboard, entering commands by speaking to the Navigator. What you see on the large, flat display screen will likely be in full color, high-definition, television-quality images, full pages of text, graphics, computer-generated animation. What you hear will incorporate high-fidelity sound, speech synthesis, and speech recognition. You will be able to work in several of these windows at any time, giving you the possibility to simultaneously compare, for example, the animated structural system of living cells with the animated network of a global economy.

Or you might want to explore the depths of Zen philosophy in which beauty is in the details, comparing it with examples of the architectural details of the Parthenon from ancient Greece and then contrasting these ideas with the design details of a Japanese camera. Various windows on the display will give you a choice of text, audio, animated graphics, or television-quality images, letting you simultaneously grasp ideas through a mix of media alternatives. Most important, the Knowledge Navigator will customize knowledge for you—it learns as you use it—to make navigating through information and ideas as interesting and understandable as possible. If you are visually oriented, you could work with the animated windows; if you are textual, you could work primarily in a text mode.

What the Navigator looks like is not as important as what it does. Just as radios and phones today come in all sizes and shapes, from a Pepsi bottle to a plastic apple, the Navigator's "form function" isn't critical. Indeed, within the next decade, the most powerful personal computer available today will be "invisible," like a motor; it will fit into a machine the size of a pocket calculator. Or it will be encased like a car engine in some highly powerful and useful new device. By then, computers may be sewn into the fabric of your shirt or embedded into the walls of your home. The Apple II chip is already small enough to wear on an earring.

Of far greater importance is how this new tool may change the way we learn, think, work, communicate and live, how it will dramatically change the computer industry from a producer of hardware or software to a producer of mass-personalized knowledge systems.

New communication and information technologies not only give us new things to think about, but new facilities to think with. The form of the printed book created a new way of organizing content and, in so doing, it promoted a new way of organizing thought. The current generation of personal computers has only hinted at the possibilities in "idea processors"—such as outlining software—for people whose product is their thinking. Bill Atkinson's Hypercard is another important step toward giving us new ways to access and organize information. Bill's dream was to create an erector set of software tools that will let us follow our natural instincts to browse through stacks of cards on our personal computer screen and then

have the capability to link to other cards by merely pointing at a word or picture on the card. The ability to interact with ideas and information in a random intuitive manner has not been possible with the relatively inflexible structure of traditional database software found on large mainframe computers. Even today we are shaping some of the root technologies which will show up in far more advanced form in our personal computers of the twenty-first century. It would give the user:

The power of a point of view. The perspective to compare and contrast and so free ourselves of the limits imposed by specialization. As Marvin Minsky says, "You don't really understand something until you understand it more than one way."

In the twenty-first century, the walls between the various areas of specialization will come down—in business, education and life. Already, a number of world-class universities, from the University of Michigan to Carnegie-Mellon, have installed computer networks on their campuses that now give them the ability to connect students with their professors and the arts with the sciences.

At Brown University, technologists have "wired" Shakespeare; they have attached little active buttons to certain words in his plays so that a curious reader can click them on to explore the deeper meaning of the tragedy of King Lear or Macbeth. Brown technologies employ an idea that computer visionary Ted Nelson had in the 1960s called Hypertext. In fact, Atkinson's Hypercard also has its roots in hypermedia. Hypertext is a branching concept, which means a user can explore in depth the links of a reference in one document with other related references or documents, going deeper and deeper into the meaning of a text. What might take hours in a library, manually flipping through a card catalog, writing down numbers and searching through the stacks, can be done casually, at any time, on any subject, at a desk at home or under a tree in the park.

If, for example, a passage suggests the cold nights King Richard's men had to battle, you can click on this passage to learn something of the weather patterns in Shakespeare's time. That discovery may trigger another question, maybe dealing with the feuds among monarchs, or the state of the British economy during the harsh winters of the sixteenth century. You can thus keep clicking onto subjects,

some of a political/social/economic nature, some totally unrelated to Shakespeare, and keep broadening *and* deepening your intellectual bandwidth.

Approaches like "marketing as theater" or the management style of the impresario might have value for business school students. The students would need easy access to information from the fields of the performing arts in order to draw connections and benefit from comparisons. The Navigator will make this possible—on and off the nation's campuses.

Analogy is a wonderful source for seeing new points of view and explaining them in ways that add depth and clarity. We can find new metaphors because we will have the ability to navigate in real time across vast frontiers of knowledge. When I first came to Silicon Valley I was startled by the constant use of metaphors. Soon it became obvious that this was the perfect way to inspire people about things that hadn't yet been created by showing analogies to things we already understood. Indeed, it will provide users access to almost all the knowledge in the world, whether it's in Texas or Timbuktu. By the early twenty-first century, all scholarly knowledge will be fully digitized, electronically sitting in computers around the world. The process has already begun. Access to this information may at first be possible only in the universities; but over a period of years its availability is likely to expand into the commercial markets where everyone will be able to enjoy its use.

Just imagine the implications. As communications theorist Neil Postman has written in *The Disappearance of Childhood,* "A group is largely defined by the exclusivity of the information its members share. If everyone knew what lawyers know, there would be no lawyers. If students knew what their teachers know, there would be no need to differentiate between them. . . . G. B. Shaw once remarked that all professions are conspiracies against the laity. We might broaden this idea to say that any group is a 'conspiracy' against those who are not in it by virtue of the fact that, for one reason or another, the 'outs' do not have access to the information possessed by the 'ins.' "

For the first time in our history, the world will have a tool that will provide not mere information, but true knowledge, cheaply and efficiently for all the "outs" and the "ins" willing to use it. People

will have the power to wander through centuries of knowledge as true explorers. We can skim the surface, occasionally diving in to incredible depths when we choose.

Our ability to exercise our point of view won't be limited to substance; it will extend to style. We will be able to stimulate our imagination by choosing the most interesting ways of navigating through knowledge which personally turns each of us on. For example, we will be able to look at the same subject in different ways at the same time—selecting from alternative media windows on the screen.

The power of simulation. Simulation may be the ultimate destiny of personal computing. It lets us say, "What if we were to try this . . ." based on some set of assumptions we can define. Personal computers do this today but we will be able to do such things in even more remarkable ways in the future.

In the future, sophisticated 3-D modeling will, for example, be possible with animated graphics and special effects as strikingly impressive as today's fantasy films—all within the control of the individual. Imagine a clothes designer who wants to see how a new fashion design might look in action. The computer would transform his simple sketch into a 3-D drawing draped on a human figure. The designer's sketch will now have been enhanced to show color, fabric texture and the smallest of details. Then the mannequin will saunter around the screen as if on a catwalk. All of this would be accomplished in real time on a twenty-first-century personal computer.

Simulation gives us the power to take risks, to experiment, to fail and try again. It will let us do extraordinary things in time compression. These are tremendous stimuli to creativity and innovation.

The power of ideas. To access source material from anywhere, with the internal artificial intelligence to draw links between ideas from totally different fields, a machine like the Navigator will require a network of informational highways just as the automobile needed roads and highways to become very useful as a transportation tool. The construction of a superhighway of knowledge will have as profound an impact on the American economy as the development of the national railroad system in the mid-1800s and the interstate highway system in the late 1950s.

Eventually, you will find yourself able to hook into a telephone "highway" (an intelligent network) to get streams of information—voice, text, and images—over the same wire simultaneously. Today, we're limited by slow modems, long log-on times, and hard-to-memorize commands to get costly information from only a few sources. By the early part of the next century, few limitations will prevail and the process will become transparent. Users won't even have to give a moment's thought to where the information resides—the tool will navigate its own way through these highways to capture it.

The Navigator will not only travel such highways. It will also perform content analysis of the information, meaning that it will tailor information to your precise needs. That's an important feature because the quantity of information in the world is doubling every three to four years. We will either cope with it or it will overwhelm us. By the early twenty-first century, the world will be suffering from information overload unless we can achieve significant changes in the way we deal with the increasing number of facts, figures, and opinions.

This tailoring of information would represent a quantum leap in the way we think and use computers—particularly because so many companies, industries, and institutions still fail to use the full benefits of existing technology. Each of our most sophisticated naval ships, for example, requires more than 20,000 pounds of paper and filing cabinets simply to hold the documentation for training, support, and maintenance. Yet all of this can be stored on a few small optical disks, weighing in at a pound or less.

Artificial intelligence will play an important role in the Knowledge Navigator. Inside the soul of the computer will be intelligent software "agents." Over time, they will become smart enough to learn that you like certain types of information presented in certain ways. The agent will learn along with you and work invisibly, turning information into useful knowledge for you.

The agent is your opinion surrogate, the ultimate objective observer. It will wander around throughout dozens of databases, pulling together whatever it thinks you, the user, are interested in. You won't have to search through the stacks of libraries—the world's largest library will exist on your desktop or your lap.

The power of enjoyment. Throughout history the telling of stories has been a fundamental way of transferring knowledge from generation to generation. Stories can illustrate, illuminate, and personalize information into scripts. Eventually, "agents" may be able to tailor information to stimulate our imagination and help make both learning and work interesting and fun.

If we can't get people excited about these tasks, then we'll never get them to be innovative and creative. Versions of the Navigator will give students the opportunity to learn at their own pace and to learn in a personalized way that is best for them. The computer can become a personal tutor that will track a student's progress, ask questions, and assign homework to correct specific weaknesses.

By customizing knowledge so each of us—individually—can learn or work at our own pace, this new personal computing device will be a tool that is fun and comfortable to use. Just as a car takes you wherever you want to go without your worrying over how the ignition key works the engine, so the Knowledge Navigator will drive you anywhere through the available store of knowledge.

Innovation will never take root in our society unless a revolution in learning begins at the start of one's education. If we had the Navigator tomorrow it would, therefore, change nothing. Widespread changes, particularly in education, must first occur if there is to be a new renaissance.

I have grown disheartened about educators' discovery that high school students show little interest in learning. Some teachers are so fatigued that they just want to shuffle students from one class to the next. There are 2,000 community colleges in the United States today, compared with only 500 back in the sixties, but they are mostly engaged in filling in the gaps of a poor high school education.

Making learning fun will also improve the self-esteem of our teachers. Educators want to feel that they are doing something important to shape the lives of their students. Too much of the discussion about education centers around budget deficits, when inadequately prepared students are being advanced through grades and when discipline in the schools has broken down. The experience of learning needs to become important and respected by society again. The process of teaching must gain recognition as the process of human resource enhancement. These are the roots of our society,

and nothing short of a revolution in American public education will be required to restore our position as innovation leader in a twenty-first-century world. If we are to turn the schools into a resource that builds the talents of our people, it is essential to make the experience of learning interesting again.

The power of creativity. The supporting premise behind the Knowledge Navigator is that innovation is the best option we have to add value in a global dynamic economy where our goal is to preserve the economic importance of America's affluent middle class. Innovation requires extraordinary personal creativity. The Navigator is a tool designed to enhance our creativity. That's where we're headed with information technology—toward mass personalized knowledge systems with transparent technology.

If we do it right and create and mass-produce such tools, we can leverage the strengths in individuality again. We can bridge the specializations to restore a balance between knowledge in depth and generalization and abstract thinking; we can generate enthusiasm for different points of view. By making the exploration of knowledge fun and interesting, the Navigator will qualify greater numbers of people for the "deeper mysteries" that will help lead us toward a new renaissance.

Ultimately we may become a society of information sharers. A tool like the Navigator could expose one of the great limitations of the printing press, too, opening the doors of knowledge to millions of people who have not been able to take advantage of one of the world's greatest inventions. As Postman notes, "The great paradox of literacy was that as it made secrets accessible, it simultaneously created an obstacle to their availability. One must qualify for the deeper mysteries of the printed page by submitting oneself to the rigors of a scholastic education. One must progress slowly, sequentially, even painfully, as the capacity for self-restraint and conceptual thinking is both enriched and expanded."

My dream is to see the Knowledge Navigator become the legitimate descendant of the Macintosh. We have come so far in the computer industry in just the past fifteen or twenty years! It proves how far we will be able to advance the technology by at least as much in the next two decades.

Seymour Cray, the founder and pioneer of Cray Computer, said it best:

"I'm exaggerating just a little bit when I tell you this story, but I think it's real, and I want to compare what's happening in the personal computer business with what's happening in the super computer business. . . . Today when you buy a $10,000 personal computer—now that is sort of the high end of the line—you can get a memory of 4 million bytes. That's the same size memory as we delivered with the CRAY-1 [in 1976]. Now that kind of astonishes me.

"It's a revolution in that industry that is as impressive as ours or more so. . . . I use an Apple Macintosh, and Apple just announced a Macintosh II. Some of you may have seen it. Do you know what they said their memory size was going to be when they expand it in the early 1990s? They said it was going to be two gigabytes. Well, do you know what two gigabytes are? That's exactly the size of the CRAY-2 memory today. So in a few years, Apple is planning to provide a memory size equal to our current supercomputer size. Now the processor probably won't be as fast, and it won't cost nearly as much, either. But they're putting multi-processors in their box as part of their plan so, I say, what does this mean?

"Well, in my mind, it's going to be a real revolution because people with minimal financial resources, individuals with out-of-pocket money, are going to be able to do physical simulations on personal computers in a few years of the kind for which they had to have a supercomputer yesterday or today. And what a revolution that might be. Instead of a few hundred customers for this kind of work, we're talking about hundreds of thousands."

Astonishingly, few major technological breakthroughs are necessary to achieve this—it's largely a question of building the critical mass of technologies that are already in motion to make the computer *a mass personalized knowledge-based system. Mass* means it has got to be affordable. *Personalized* means it will be easily adaptable to the individual's needs and tasks. *Knowledge-based* suggests a major leap from solely providing information. Wisdom, reflection, points of view, and opinion will be offered by the new technology.

System means we need an infrastructure of intelligent information networks analogous to the infrastructure of highways that was needed to transform the automobile industry into a mass personalized transportation system.

For those interested in technology, the details of what we can do and what we will soon be able to do are fascinating. We will require a "distributed database" under which all information we could possibly desire is accessible to the Navigator regardless of where those data reside in the world. Today, the necessary distributed processing technology is fast becoming a commercial reality, and new database technology offers one of the most exciting opportunities for growth and new uses of personal computing in the 1990s.

To better handle all this information, we also will need a dramatic reduction in the cost of active memory and mass storage memory technology. These are both reasonable expectations over the next thirteen years. Memory expansion is crucial for three-dimensional simulations and animation on the computer screen.

A revolution is about to occur in mass storage as optical media becomes a full commercial reality. Optical media in the form of CD-ROMs, which look like stereo compact disks, is one of the most exciting developments ahead. A single CD-ROM can hold more than 500 megabytes of data, which is equivalent to putting the entire twenty-six volumes of an encyclopedia on a single disk! Large libraries of text, sound and television-quality pictures can now be etched on the small round pieces of plastic by precision laser beams.

Next, we will want all the important information in the world to be digitized and electronically scored (meaning scanned or typed into computers) so it can be retrieved by personal computers. As awesome as that may sound, it's a likely probability sometime early in the twenty-first century. Already, savvy investors are buying up the rights to many databases in the belief that they will be very valuable in the next century, just as investors previously bought up the rights to old film libraries.

We also should expect to see a wide choice of digitized media, from speech and text to animated computer-generated images and full-color, high-resolution TV-quality video, on a computer screen. Imagine watching Dan Rather deliver the news in one window of the Knowledge Navigator screen, while simultaneously your computer

brings up relevant facts and links to other aspects of the same story he is reporting. The computer would generate only what it knows you might enjoy from its experience of working with you.

Then, the use of such mixed media will require multiple processors working at the same time. The microprocessor is the computer's brain. In the early twenty-first century, that brain will be one hundred times faster yet cost no more. Yet if we add more of them to each computer, we can obviously boost performance to even greater levels, since several processors can share the load of handling data in a single program. That could significantly speed up the process of doing long, complex tasks and becomes particularly important in 3-D imaging, speech recognition, and high-resolution animation.

Parallel processing is no easy task, however. Learning to write programs for parallel processor computers looms as one of the biggest challenges because all our computer science knowledge has been directed toward the single linear processor architecture first envisioned by Turing and von Neuman nearly fifty years ago. Co-processing, on the other hand, is a closer reality. This technology requires several processors to be programmed separately to support several different dedicated tasks that can run on the personal computer at the same time.

In addition, trends already are underway that will lead to the eventual convergence of telecommunications and personal computing. The essential worldwide network and communications standards are already being defined. These necessary efforts are supported by all the major telecommunications and computer companies around the world.

Finally, we don't want information, only access to better information that interests us individually. What we really want is to be able to understand better. Ideally, we want the computer to do the hard work of figuring out what is important, drawing relationships between data from different sources and performing analysis on it. What we need, then, is a very sophisticated level of a knowledge-based system better known as artificial intelligence.

This is where significant breakthroughs are still necessary for the Navigator to be a reality. But much work is underway and incubating at the best universities, research laboratories, and start-up companies to make this more than a possibility in the early twenty-

first century. Typically, it takes ten to fifteen years before such work slips out of the university lab and into commercial use.

Computer pioneers throughout the country are pushing the edge of the envelope, exploring concepts and ideas that once were mere dreams. Douglas Hofstadter, author of *The Mind's I,* has been working at the University of Michigan with the theory of analogy as the basis for artificial intelligence. Doug Lenat, a brilliant computer scientist at the Micro Computer Consortium in Austin, Texas, has undertaken one of the most ambitious AI projects. He is creating a total encyclopedic knowledge base to be linked and accessed by the computer using principles of common sense.

Meantime, however, we will see a continued explosion in expert systems. An expert system takes the wisdom of individual experts and interprets their experience into a long list of rules to follow under various conditions. Expert systems have unique software which uses predefined rules based on expert experience combined with the ability of the computer to infer probable answers. An expert system allows the user to ask questions in plain English and get answers back in English. But whatever intelligence it may appear to have is limited to the imputed experience or rules built into its inference engine.

While expert systems are an important step, the Navigator must have innate intelligence of its own. The real distinction between expert systems and artificial intelligence is the ability of the computer to be able to learn from its own experience. Only true artificial intelligence will allow computers to become smarter over time. Computer scientists have been dreaming of the possibilities of artificial intelligence for over three decades. Yet the more they learn, the more they realize how little we know.

Still, this exploration is unfolding some fascinating developments. Some of the best researchers in this field at MIT have just learned to create digitized cockroaches that incredibly set their own willful, deliberate tracks over a programmed terrain. Of course, these roaches look primitive, almost silly, like images straight from the light show at the old Fillmore East. Their slow lumbering movements can't compare with the fabulous antics of the simplest Disney creatures. But then Mickey and Minnie Mouse are really puppets follow-

ing completely their animators' will—not their own! These roaches are the "prehistorical" incarnation of our agents.

Marvin Minsky and Seymour Pappert, long-time collaborators at MIT in artificial intelligence, are trying to understand how the human mind works. They are particularly focusing on the mind of the child because it is less complicated by experience than the mind of the adult. In Minsky's book *The Society of Minds* he envisions the mind as a vast society of very small and very simple modules, each having the capability to carry out specific tasks. Consider the beehive: Each worker bee has relatively low intelligence, but when you put thousands of them together, they take on a high level of brilliance. AI may work on this very premise: that clusters of "agents" will assume higher levels of intelligence. In trying to unravel how these agents cross-connect and associate with each other, he hopes to discover how intelligent computers of the future may be designed to do the same. But to scale this theory up to the level of the human mind is an awesome task. The human brain is estimated to have over 10 billion neurons—equivalent to individual processors—with over 10 trillion interconnections (synapse junctions).

As Yale psychologist Roger Schank points out, "at the root of our ability to understand is our ability to find the most relevant memory at just the right time." He defines a memory organization as one based on an indexing scheme of failure-driven events. Put simply, we learn best by remembering our mistakes. His work is directed toward writing little scripts based on trial and error experience as a way of understanding the dynamic nature of human memory.

Myriad steps are required to get there, and they are being taken all over the country by hundreds of pioneers. Consider the development of Danny Hillis's Connection Machine. As he says only partly in jest: "We want to build a computer that will be proud of us." He's well on his way. A software program called the Indexor is now capable of indexing every word in a full-length novel in less than a second. This is an essential technology for content analysis of vast databases, since we must have the potential to link every word with every other word to draw logical patterns of content understanding. The computer could therefore search for patterns of recurring ideas and connected themes between different documents, which would

otherwise be physically difficult, if not impossible. The Connection Machine uses what is called massive parallelism, or literally hundreds of thousands of microprocessors in one computer. Today's personal computer uses all of one processor. The personal computer of tomorrow will likely use several.

Another alternative to artificial intelligence is the neural network. It takes a very different approach. It is founded on the observation that the human brain is composed of billions of neurons connected through synaptic junctions, with each neuron acting as a potential neural chemical transmitter. In a neural network computer, many small individual processors called perceptrons are linked to each other. Statistical weighing is used as the basis to determine clusters and patterns of individual processors which either promote or inhibit activity. Conventional computer logic forces answers into discrete true or false categories. Neural networks can make judgments of approximation.

Already, there have been successful experiments of neural networks learning from their own trial and experience. They start out rather dumb, but in a matter of hours are able to become quite accomplished at such tasks as handwriting and speech recognition.

Twenty years ago, Alan Kay envisioned the Dynabook, which became the progenitor of the personal computer. The Dynabook was a small, compact computer, something that could be tucked under the arm and carried like a notebook. It could recognize handwriting and tap into large computers via radio frequency. Kay never built the product, but he and others became so excited by his vision of what it could be that it spurred a revolution in computing.

Vivarium may never get completed, either, just like Dynabook. But along the way, Kay and others who have rallied around the project will make the discoveries necessary to give us the pieces to complete the Navigator. Bill Atkinson's Hypercard, too, the next logical step to making computers truly accessible to people, is another of the building blocks for the next revolution.

The most exciting part of the odyssey lies ahead. It's everyone's odyssey. But we must do something now because there will be no quick fixes in the twenty-first century. We must revolutionize our

institutions, using our technologies and our people as vast resources. If America is to regain its competitive edge, it will have to regain the initiative in innovation and creativity. It may well take a full generation, at least twenty years, for this to occur—a perspective few Americans seem capable of taking.

Consider the twelfth-century cathedral. Each one took more than a hundred years to complete, and workers could spend a lifetime without seeing either the beginning or the end of the building. Yet the cathedral was a mirror of its age—an age measured not in years but in centuries. It was a project of experimentation. Structural design was achieved not through scientific formulas of load factors and stress equations but through a process of trial and error, guided, of course, by master masons who had a wealth of practical experience. The master builders behind these projects didn't have clearly defined goals in mind, only clear directions of where they were headed. During their journey of construction and experimentation, they never regarded their work as finished; they kept pushing their goals beyond all limits. It was management by direction, not management by objectives.

We, too, must be ready to reach for a new direction through risky trial and error, through a workforce that has pride in the things it does, often prepared to undertake a journey which will exceed its own lifetime.

Such tools, such aims, may help us realize the potential of the very best elements in our society.

The United States has a chance of creating a twenty-first-century renaissance . . . if we can learn to make the heterogeneous character of our country an asset again. Despite the weaknesses of our public elementary and secondary school systems, we have as a nation an extremely good higher education system. It's a fact recognized by the large and growing number of foreigners who attend our best universities. It's also no surprise that the single largest contributor to a region's economic health is the strength of its educational community. Silicon Valley sprouted from open apricot and prune fields in part because of its proximity to Stanford University; Harvard and MIT have had the same effect on the emergence of Boston's Route 128 as a haven for entrepreneurial activity.

As the artificial walls of our great universities come tumbling

down through technology, and as electronic networks expand the reach of university campuses, the range of influence of higher education will increase. Libraries, as noted, will no longer be bound by bricks and mortar but will be electronically connected to students far from the physical campus. The teaching skills of the best professors at the best universities will be available by "template" to anyone who wants to learn. The universities in networks of interdependencies can indeed become the models of the new institutions in this new renaissance.

If the next renaissance will be based on a new age of individualism, the United States has many of the right attributes to enhance the individual's stature in the world. In Japan, it is not inherent in the rigid social order to champion the individual. While Japanese team accomplishments, pride, and morale are extraordinary, the Japanese are less likely to achieve the cosmic breakthrough of a Bill Atkinson or an Alan Kay. The rigidity of Japanese society and the aging of its population leave some doubt about the country's ability to quickly adjust to new paradigms for learning, working, and communicating. Yet we must not disregard the high respect Japanese have for education and family and their ability to assimilate new outside philosophies without abandonment of their traditions.

Europe also seems less likely as the place for another renaissance. Though blessed with bright, educated people and a rich culture, Europe remains overly institutionalized and bound by near unshakable traditions that look backward rather than ahead. Europe is constantly expending its energies in opposing directions between the fragmentation of nationalistic interests and the oversimplification of pan–European alliances which often fail to live up to their lofty objectives.

It's interesting to note that the Soviet Union is the only sophisticated country in which the Renaissance never occurred—largely because it is a country which has no respect for the individual. Up until ten years ago, even the copying machines in that country were kept under lock and key.

The genetic code of America has been defined as one of heterogeneous revolutionaries and immigrants. They can be the source of strength for us in the future as they have been in the past. We still have the best chance of launching the twenty-first-century renaissance if a consensus of Americans grasps the seriousness of the crisis ahead—losing our affluent middle class—and seizes on the equally imposing opportunities we have to use technology and education to build on our strengths.

The Japanese may seem to have many advantages over us—their understanding of the global economy, their use of technology, and even their creativity. It is naive to call them mere copiers as many critics have suggested. Their creativity is channeled into product miniaturization and quality maximization. They see that the beauty of Buddha is in the details while we in America are more conscious of creativity at a larger, more obvious level.

But Japan, now being severely tested by its less developed neighbors, draws upon the intellect and strength of only half its workforce. Although many women in Japan are employed in clerical or assembly-line jobs, they have not been tapped as a significant resource for management jobs.

As we shift toward a work world which learns to leverage intuitive and creative skills, women will emerge as the country's most important hidden resource. Some 30 percent of the students in the nation's top business schools today are women. A disproportionate share of them also are getting the high honors and distinctions in our universities. At Apple, where 50 percent of our managers are female, some 70 percent of our performance awards for management last year went to women.

If creativity and innovation are important in regaining our world competitiveness, women leaders may prove ideally suited for our own country's renewal. Many of the characteristics of the new-age leader are the typical personality traits that women possess.

Steve Jobs will be especially significant to all of us on the voyage out of this century. His beliefs and actions helped us dream of how to restore the individual's power in a society thick with institutions. His motivating idea—that we can change the world one person, one computer at a time—was fundamentally right. So Apple and many others have proven and are continuing to prove.

In some way, I want Apple to be the living laboratory for the model corporation of this new century. As new discoveries appear,

new ideas will occur inside the company. Ideas will constantly be refreshed over time. Other corporations, such as AT&T, now find themselves consumed trying to disassemble all the things which prevent them from turning into true twenty-first-century companies. Whether we succeed or not isn't as important as the fact that we will aim for that direction and ask the insightful questions.

At Apple, we think in terms of "paradigms" to help us adapt to change, to remind us of the plastic nature of categories; it helps us realize we all wear blinders created by our culture, our language, and our attitudes. As Thomas Kuhn wrote in *The Structure of Scientific Revolutions,* when Sir William Herschel discovered in the late 1700s that Uranus was not a comet but a planet, he opened the eyes of other astronomers to the existence of new planets everywhere.

His discovery had far-reaching consequences: it triggered a paradigm shift. Before that discovery, every scientist saw a galaxy populated by fleeting comets; suddenly they were thinking in terms of the greater permanence of planets. In the first fifty years of the nineteenth century, twenty "new" planets were discovered. It was almost as if astronomers lived in a different world. We are now on the verge of a massive shift in the paradigm.

Our transition toward this "new vision of reality" has been a wrenching roller coaster ride—yet one that is part and parcel of the new reality of constant change. Ilya Prigogine, the Russian-born Nobel laureate, perhaps described it best by drawing from the world of physics in noting that order often follows chaos. Instability imposes revolutionary change when managements may only be ready to instigate change in increments. The disorder leads to what Prigogine terms a bifurcation point at which the organization can either crumble into chaos, as many businesses have, or jump to a new, higher level of order. Crisis can often have value because it generates transformation. In a sense, Apple had reached the bifurcation stage during its severe downturn. Our chaos, however, led to the creation of a new, different, and stronger entity whose roots still remain intact.

Apple is in the business of making tools for the individual. These tools are only going to get better and better and may well be the key to education reform, reintroducing creativity and individual resourcefulness as our most important natural resource in the information age. Innovation, I believe, is the only way that America will regain the initiative in a global dynamic economy. The way to increase our productivity is to make people more creative, resourceful, and innovative in the things they do.

It means a right-brain, intuitive tilt for the country which will take at least a generation to implement. But the rewards could possibly lead to another renaissance and a tremendous increase in productivity which will be hard for other nations to match. The roots of our American society are perhaps better suited to this change in the ground rules for world competitiveness than any other country in the world. Americans are by nature an individualistic and resourceful people once we see the way.

I sometimes think of where the world was before Apple began ten short years ago, and of how far we've come.... It's as if we already are a twenty-first-century company that has miraculously been able to come back to the late twentieth century to make sure we don't fail or compromise our mission along the way.

But I'm also aware of how far all of us must go to discard the industrial-age models of economics, business, and education and replace them with the new ideas and paradigms of the information age. I feel sure that the next thirteen years will transform the world. We are still at the very beginning of the information age.

When Napoleon Bonaparte wanted to extend the reach of his armies, he believed he should allow them to march in the heat of the summer. So strong were the sun's rays that he proposed lining the major roads in France with shaded trees.

One of his ministers responded in shocked amazement:

"But Emperor Napoleon, they will take thirty years to grow!"

Replied the adventurer who created a French empire: "Then we don't have a moment to waste!"