

THE FIFTH GENERATION

Artificial Intelligence and
Japan's Computer Challenge
to the World

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&

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**THE
FIFTH GENERATION**

To H.P.N. and J.F.T.

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Following the example of Henry Adams, we appear here as characters in our own book. Since one of us, Feigenbaum, has played an active role in the story we tell, and since both of us represent distinct though concordant points of view, to efface ourselves would not only have blurred those distinctions but might have hidden from the reader our special interests in the whole topic. We are decidedly not disinterested observers.

In the matter of Japanese names we have been inconsistent, but our inconsistency has a purpose. We have simply chosen the form that most Westerners are likely to be familiar with: thus the novelist Murasaki Shikibu appears with her surname first, whereas our contemporaries, like Kazuhiro Fuchi, appear with surnames last.

January 1983

E.A.F. and P.M.

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Epilog, or

It Is Hard to Predict,

Especially the Future

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PROLOG

Time magazine's "Man of the Year" for 1982 was not a man at all, but a machine—the computer. The computer revolution has barely begun, but already we see a startling penetration of computers in most forms of work people do, their gadgets and machinery, and their entertainment. The economists tell us that we have become a nation of knowledge workers: more than half of us are engaged in the various forms of knowledge and information processing. The computer is the knowledge worker's tool, as the planting and harvesting machines are to the farmer and the heavy industrial machines are to the manufacturing worker. The ascendancy of the knowledge worker is reflected in the ascendancy of the tool—the computer. It has been a long time since a child of technology has had such a profound effect upon our lives and our society.

Knowledge is power, and the computer is an amplifier of that power. We are now at the dawn of a new computer revolution. *Business Week* featured it as "the second computer age." We view it as the important computer revolution, the transition from information processing to knowledge processing, from computers that calculate and store data to computers that reason and inform. Artificial intelligence is emerging from the laboratory and is beginning to take its place in human affairs. Professor Allen Newell of Carnegie-Mellon University, a pioneer of artificial intelligence, once wrote that "computer technology offers the possibility of incorporating intelligent behavior in all the nooks and crannies of our world." The nooks and crannies are right now being filled with computers, and the intelligent behavior is following quickly along.

The American computer industry has been innovative, vital, and successful. It is, in a way, the ideal industry. It creates value by transforming the brainpower of the knowledge workers, with little consumption of energy and raw materials. Today we dominate the world's ideas and markets in this most important of all modern technologies. But what about tomorrow?

The Japanese have seen gold on distant hills and have begun to move out. Japanese planners view the computer industry as vital to their nation's economic future and have audaciously made it a national goal to become number one in this industry by the latter half of the 1990s. They aim not only to dominate the traditional forms of the computer industry but to establish a "knowledge industry" in which knowledge itself will be a salable commodity like food and oil. Knowledge itself is to become the new wealth of nations.

To implement this vision the Japanese have both strategy and tactics. Their strategy is simple and wise: to avoid a head-on confrontation in the marketplace with the currently dominant American firms; instead to look out into the 1990s to find an arena of great economic potential that is currently being overlooked by the more shortsighted and perhaps complacent American firms; to move rapidly now to build major strength in that arena. The tactics are set forth in a major and impressive national plan of the Ministry of International Trade and Industry (MITI) called Fifth Generation Computer Systems. The plan documents a carefully staged ten-year research and development program on Knowledge Information Processing Systems. The implementation began in April 1982 with the formation of the Institute for New Generation Computer Technology (ICOT) and coordinated laboratories of the major Japanese firms in the computer industry.

The Japanese plan is bold and dramatically forward-looking. It is unlikely to be completely successful in the ten-year period. But to view it therefore as "a lot of smoke," as some American industry leaders have done, is a serious mistake. Even partially realized concepts that are superbly engineered can have great economic value, preempt the market, and give the Japanese the dominant position they seek.

We now regret our complacency in other technologies. Who in the 1960s took seriously the Japanese initiative in small cars? Who in 1970 took seriously the Japanese national goal to become number one in consumer electronics in ten years? (Have you seen an American VCR that isn't Japanese on the inside?) In 1972, when the Japanese had yet to produce their first commercial microelectronic chip but announced their national plans in this vital "made in America" technology, who would have thought that in ten years they would have half of the world's market for the most advanced memory chips? Are we about to blow it again? The consequences of complacency, of our spirited attention to the near-in at the expense of the long view, will be devastating to the economic health of our most important industry. The Japanese could thereby become the dominant industrial power in the world.

We are writing this book because we are worried. But we are also basically optimistic. Americans invented this technology! If only we could focus our efforts, we should have little trouble dominating the second computer age as we dominated the first. We have a two- or three-year lead; that's large in the world of high technology. But we are squandering our lead at the rate of one day per day.

America needs a national plan of action, a kind of space shuttle program for the knowledge systems of the future. In this book we have tried to explain this new knowledge technology, its roots in American and British research, and the Japanese Fifth Generation plan for extending and commercializing it. We have also outlined America's weak, almost non-existent response to this remarkable Japanese challenge. The stakes are high. In the trade wars, this may be the crucial challenge. Will we rise to it? If not, we may consign our nation to the role of the first great postindustrial agrarian society.

PART



THE NEW
WEALTH OF NATIONS

1

REASON AND REVOLUTION

The reasoning animal has finally made the reasoning machine.

Who dares feign surprise at the inevitable? It's human to exhibit intelligence, and human to make machines. The combination, not to say the collision, of the two is the most human of stories.

The making of a reasoning machine requires a special ingredient, not secret exactly, but not something we're born with either: the getting of it is the begetting of intelligence. That special ingredient is knowledge. Knowledge is not the same as information. Knowledge is information that has been pared, shaped, interpreted, selected, and transformed; the artist in each of us daily picks up the raw material and makes of it a small artifact—and at the same time, a small human glory. Now we have invented machines to do that, just as we invented machines to extend our muscles and our other organs. In typical human fashion, we intend our new machines for all the usual purposes, from enhancing our lives to filling our purses. If they scourge our enemies, we wouldn't mind that either.

This version of the story is less about the reasoning machines themselves than the reasoning animals who've made the first (and admittedly primitive) examples, and the reasoning animals who are bent on mass-producing them. The mass production is a clue to one of the themes that recur here, namely, the changes in quality wrought by changes in quantity, what scientists know as the "order of magnitude" effect.

In an otherwise unremarkable office building in Tokyo, a group of highly dedicated young researchers is engaged in designing a new computer generation that will transform the way the Japanese work, whether they are fishermen or powerful business executives, farmers or shopkeepers, scientists or schoolchildren. The vehicles of revolution are to be known as knowledge information processing systems, or KIPS. This new generation of computers will be more powerful than any other the world has seen—indeed, by orders of magnitude. But their real power will lie

not in their processing speed, but in their capacity to reason. They will reason, moreover, with enormous amounts of information that will be constantly selected, interpreted, updated, and adapted as circumstances change those facts. KIPS are intended to bring knowledge—large amounts of it, tailored to any given user's needs—to any task a user might wish to do.

The Japanese expect these new computers, which users will be able to speak with in everyday conversational language, or show pictures to, or transmit messages to by keyboard or handwriting, to penetrate every level of society. They will assume no special expertise or knowledge of arcane programming languages. They will not even require the user to be very specific about his needs, because they will have reasoning power and will be able to tease out from the user, by questioning and by suggestions, just exactly what it is the user wants to do or know. Finally, these new machines will be inexpensive and reliable enough to be used everywhere, in offices, factories, restaurants, shops, farms, and fisheries, and of course, homes.

The Japanese expect these computers to be the core computers—that is, the computers most generally in use worldwide—by the 1990s. They expect such powerful reasoning and knowledge processing to transform their society. At the same time, they expect those same machines to save their society, too. Because they see no economic alternative for themselves in the long run, the Japanese will not only broker knowledge itself to the world, but they will also sell products and services whose design is so knowledge-intensive that their superiority must inevitably claim a large proportion of world markets.

How revolution, transformation, and salvation are all to be carried out is one of the topics of this book. How other countries will be affected by Japan's revolution, and how they are already beginning to respond to it, is another. That other countries must respond somehow, and what the penalties of an ill-considered response are, is still a third.

Throughout there are great themes. We have already spoken of one recurrent theme, how quantitative changes eventually bring about qualitative changes, the "order of magnitude" effect. Then there's the theme of courage and its rewards, and cowardice, or foolishness, and its costs. There's the hazard of new fortunes and the worse hazard of no fortune at all.

But the overarching theme is the centrality of knowledge in human life, now and in the future. As everybody knows, knowledge is power. Machines that can amplify human knowledge will amplify every dimension of power.