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THE WORLD IS FLAT

A Brief History of the Twenty-first Century

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ONE

While I Was Sleeping

Your Highnesses, as Catholic Christians, and princes who love and promote the holy Christian faith, and are enemies of the doctrine of Mahomet, and of all idolatry and heresy, determined to send me, Christopher Columbus, to the above-mentioned countries of India, to see the said princes, people, and territories, and to learn their disposition and the proper method of converting them to our holy faith; and furthermore directed that I should not proceed by land to the East, as is customary, but by a Westerly route, in which direction we have hitherto no certain evidence that anyone has gone.

—Entry from the journal of Christopher Columbus on his voyage of 1492

No one ever gave me directions like this on a golf course before: "Aim at either Microsoft or IBM." I was standing on the first tee at the KGA Golf Club in downtown Bangalore, in southern India, when my playing partner pointed at two shiny glass-and-steel buildings off in the distance, just behind the first green. The Goldman Sachs building wasn't done yet; otherwise he could have pointed that out as well and made it a threesome. HP and Texas Instruments had their offices on the back nine, along the tenth hole. That wasn't all. The tee markers were from Epson, the printer company, and one of our caddies was wearing a hat from 3M. Outside, some of the traffic signs were also sponsored by Texas Instruments, and the Pizza Hut billboard on the way over showed a steaming pizza, under the headline "Gigabites of Taste!"

No, this definitely wasn't Kansas. It didn't even seem like India. Was this the New World, the Old World, or the Next World?

I had come to Bangalore, India's Silicon Valley, on my own Columbus-like journey of exploration. Columbus sailed with the *Niña*, the *Pinta*, and the *Santa María* in an effort to discover a shorter, more direct route to India by heading west, across the Atlantic, on what he presumed to be an open sea route to the East Indies—rather than going south and east around Africa, as Portuguese explorers of his day were trying to do. India and the magical Spice Islands of the East were famed at the time for their gold, pearls, gems, and silk—a source of untold riches. Finding this shortcut by sea to India, at a time when the Muslim powers of the day had blocked the overland routes from Europe, was a way for both Columbus and the Spanish monarchy to become wealthy and powerful. When Columbus set sail, he apparently assumed the Earth was round, which was why he was convinced that he could get to India by going west. He miscalculated the distance, though. He thought the Earth was a smaller sphere than it is. He also did not anticipate running into a landmass before he reached the East Indies. Nevertheless, he called the aboriginal peoples he encountered in the new world "Indians." Returning home, though, Columbus was able to tell his patrons, King Ferdinand and Queen Isabella, that although he never did find India, he could confirm that the world was indeed round.

I set out for India by going due east, via Frankfurt. I had Lufthansa business class. I knew exactly which direction I was going thanks to the GPS map displayed on the screen that popped out of the armrest of my airline seat. I landed safely and on schedule. I too encountered people called Indians. I too was searching for the source of India's riches. Columbus was searching for hardware—precious metals, silk, and spices—the source of wealth in his day. I was searching for software, brainpower, complex algorithms, knowledge workers, call centers, transmission protocols, breakthroughs in optical engineering—the sources of wealth in our day. Columbus was happy to make the Indians he met his slaves, a pool of free manual labor.

I just wanted to understand why the Indians I met were taking our work, why they had become such an important pool for the outsourcing

of service and information technology work from America and other industrialized countries. Columbus had more than one hundred men on his three ships; I had a small crew from the Discovery Times channel that fit comfortably into two banged-up vans, with Indian drivers who drove barefoot. When I set sail, so to speak, I too assumed that the world was round, but what I encountered in the real India profoundly shook my faith in that notion. Columbus accidentally ran into America but thought he had discovered part of India. I actually found India and thought many of the people I met there were Americans. Some had actually taken American names, and others were doing great imitations of American accents at call centers and American business techniques at software labs.

Columbus reported to his king and queen that the world was round, and he went down in history as the man who first made this discovery. I returned home and shared my discovery only with my wife, and only in a whisper.

"Honey," I confided, "I think the world is flat."

How did I come to this conclusion? I guess you could say it all started in Nandan Nilekani's conference room at Infosys Technologies Limited. Infosys is one of the jewels of the Indian information technology world, and Nilekani, the company's CEO, is one of the most thoughtful and respected captains of Indian industry. I drove with the Discovery Times crew out to the Infosys campus, about forty minutes from the heart of Bangalore, to tour the facility and interview Nilekani. The Infosys campus is reached by a pockmarked road, with sacred cows, horse-drawn carts, and motorized rickshaws all jostling alongside our vans. Once you enter the gates of Infosys, though, you are in a different world. A massive resort-size swimming pool nestles amid boulders and manicured lawns, adjacent to a huge putting green. There are multiple restaurants and a fabulous health club. Glass-and-steel buildings seem to sprout up like weeds each week. In some of those buildings, Infosys employees are writing specific software programs for American or European companies; in others, they are running the back rooms of major

American- and European-based multinationals—everything from computer maintenance to specific research projects to answering customer calls routed there from all over the world. Security is tight, cameras monitor the doors, and if you are working for American Express, you cannot get into the building that is managing services and research for General Electric. Young Indian engineers, men and women, walk briskly from building to building, dangling ID badges. One looked like he could do my taxes. Another looked like she could take my computer apart. And a third looked like she designed it!

After sitting for an interview, Nilekani gave our TV crew a tour of Infosys's global conferencing center—ground zero of the Indian outsourcing industry. It was a cavernous wood-paneled room that looked like a tiered classroom from an Ivy League law school. On one end was a massive wall-size screen and overhead there were cameras in the ceiling for teleconferencing. "So this is our conference room, probably the largest screen in Asia—this is forty digital screens [put together]," Nilekani explained proudly, pointing to the biggest flat-screen TV I had ever seen. Infosys, he said, can hold a virtual meeting of the key players from its entire global supply chain for any project at any time on that supersize screen. So their American designers could be on the screen speaking with their Indian software writers and their Asian manufacturers all at once. "We could be sitting here, somebody from New York, London, Boston, San Francisco, all live. And maybe the implementation is in Singapore, so the Singapore person could also be live here . . . That's globalization," said Nilekani. Above the screen there were eight clocks that pretty well summed up the Infosys workday: 24/7/365. The clocks were labeled US West, US East, GMT, India, Singapore, Hong Kong, Japan, Australia.

"Outsourcing is just one dimension of a much more fundamental thing happening today in the world," Nilekani explained. "What happened over the last [few] years is that there was a massive investment in technology, especially in the bubble era, when hundreds of millions of dollars were invested in putting broadband connectivity around the world, undersea cables, all those things." At the same time, he added, computers became cheaper and dispersed all over the world, and there was an explosion of software—e-mail, search engines like Google, and

proprietary software that can chop up any piece of work and send one part to Boston, one part to Bangalore, and one part to Beijing, making it easy for anyone to do remote development. When all of these things suddenly came together around 2000, added Nilekani, they "created a platform where intellectual work, intellectual capital, could be delivered from anywhere. It could be disaggregated, delivered, distributed, produced, and put back together again—and this gave a whole new degree of freedom to the way we do work, especially work of an intellectual nature . . . And what you are seeing in Bangalore today is really the culmination of all these things coming together."

We were sitting on the couch outside of Nilekani's office, waiting for the TV crew to set up its cameras. At one point, summing up the implications of all this, Nilekani uttered a phrase that rang in my ear. He said to me, "Tom, the playing field is being leveled." He meant that countries like India are now able to compete for global knowledge work as never before—and that America had better get ready for this. America was going to be challenged, but, he insisted, the challenge would be good for America because we are always at our best when we are being challenged. As I left the Infosys campus that evening and bounced along the road back to Bangalore, I kept chewing on that phrase: "The playing field is being leveled."

What Nandan is saying, I thought, is that the playing field is being flattened . . . Flattened? Flattened? My God, he's telling me the world is flat!

Here I was in Bangalore—more than five hundred years after Columbus sailed over the horizon, using the rudimentary navigational technologies of his day, and returned safely to prove definitively that the world was round—and one of India's smartest engineers, trained at his country's top technical institute and backed by the most modern technologies of his day, was essentially telling me that the world was *flat*—as flat as that screen on which he can host a meeting of his whole global supply chain. Even more interesting, he was citing this development as a good thing, as a new milestone in human progress and a great opportunity for India and the world—the fact that we had made our world flat!

In the back of that van, I scribbled down four words in my notebook: "The world is flat." As soon as I wrote them, I realized that this was the

underlying message of everything that I had seen and heard in Bangalore in two weeks of filming. The global competitive playing field was being leveled. The world was being flattened.

As I came to this realization, I was filled with both excitement and dread. The journalist in me was excited at having found a framework to better understand the morning headlines and to explain what was happening in the world today. Clearly, it is now possible for more people than ever to collaborate and compete in real time with more other people on more different kinds of work from more different corners of the planet and on a more equal footing than at any previous time in the history of the world—using computers, e-mail, networks, teleconferencing, and dynamic new software. That is what Nandan was telling me. That was what I discovered on my journey to India and beyond. And that is what this book is about. When you start to think of the world as flat, a lot of things make sense in ways they did not before. But I was also excited personally, because what the flattening of the world means is that we are now connecting all the knowledge centers on the planet together into a single global network, which—if politics and terrorism do not get in the way—could usher in an amazing era of prosperity and innovation.

But contemplating the flat world also left me filled with dread, professional and personal. My personal dread derived from the obvious fact that it's not only the software writers and computer geeks who get empowered to collaborate on work in a flat world. It's also al-Qaeda and other terrorist networks. The playing field is not being leveled only in ways that draw in and superempower a whole new group of innovators. It's being leveled in a way that draws in and superempowers a whole new group of angry, frustrated, and humiliated men and women.

Professionally, the recognition that the world was flat was unnerving because I realized that this flattening had been taking place while I was sleeping, and I had missed it. I wasn't really sleeping, but I was otherwise engaged. Before 9/11, I was focused on tracking globalization and exploring the tension between the "Lexus" forces of economic integration and the "Olive Tree" forces of identity and nationalism—hence my 1999 book, *The Lexus and the Olive Tree.* But after 9/11, the olive tree wars became all-

consuming for me. I spent almost all my time traveling in the Arab and Muslim worlds. During those years I lost the trail of globalization.

I found that trail again on my journey to Bangalore in February 2004. Once I did, I realized that something really important had happened while I was fixated on the olive groves of Kabul and Baghdad. Globalization had gone to a whole new level. If you put *The Lexus and the Olive Tree* and this book together, the broad historical argument you end up with is that that there have been three great eras of globalization. The first lasted from 1492—when Columbus set sail, opening trade between the Old World and the New World—until around 1800. I would call this era Globalization 1.0. It shrank the world from a size large to a size medium. Globalization 1.0 was about countries and muscles. That is, in Globalization 1.0 the key agent of change, the dynamic force driving the process of global integration was how much brawn—how much muscle, how much horsepower, wind power, or, later, steam power—your country had and how creatively you could deploy it. In this era, countries and governments (often inspired by religion or imperialism or a combination of both) led the way in breaking down walls and knitting the world together, driving global integration. In Globalization 1.0, the primary questions were: Where does my country fit into global competition and opportunities? How can I go global and collaborate with others through my country?

The second great era, Globalization 2.0, lasted roughly from 1800 to 2000, interrupted by the Great Depression and World Wars I and II. This era shrank the world from a size medium to a size small. In Globalization 2.0, the key agent of change, the dynamic force driving global integration, was multinational companies. These multinationals went global for markets and labor, spearheaded first by the expansion of the Dutch and English joint-stock companies and the Industrial Revolution. In the first half of this era, global integration was powered by falling transportation costs, thanks to the steam engine and the railroad, and in the second half by falling telecommunication costs—thanks to the diffusion of the telegraph, telephones, the PC, satellites, fiber-optic cable, and the early version of the World Wide Web. It was during this era that we really saw the

birth and maturation of a global economy, in the sense that there was enough movement of goods and information from continent to continent for there to be a global market, with global arbitrage in products and labor. The dynamic forces behind this era of globalization were breakthroughs in hardware—from steamships and railroads in the beginning to telephones and mainframe computers toward the end. And the big questions in this era were: Where does my company fit into the global economy? How does it take advantage of the opportunities? How can I go global and collaborate with others through my company? *The Lexus and the Olive Tree* was primarily about the climax of this era, an era when the walls started falling all around the world, and integration, and the backlash to it, went to a whole new level. But even as the walls fell, there were still a lot of barriers to seamless global integration. Remember, when Bill Clinton was elected president in 1992, virtually no one outside of government and the academy had e-mail, and when I was writing *The Lexus and the Olive Tree* in 1998, the Internet and e-commerce were just taking off.

Well, they took off—along with a lot of other things that came together while I was sleeping. And that is why I argue in this book that around the year 2000 we entered a whole new era: Globalization 3.0. Globalization 3.0 is shrinking the world from a size small to a size tiny and flattening the playing field at the same time. And while the dynamic force in Globalization 1.0 was countries globalizing and the dynamic force in Globalization 2.0 was companies globalizing, the dynamic force in Globalization 3.0—the thing that gives it its unique character—is the newfound power for *individuals* to collaborate and compete globally. And the lever that is enabling individuals and groups to go global so easily and so seamlessly is not horsepower, and not hardware, but software—all sorts of new applications—in conjunction with the creation of a global fiber-optic network that has made us all next-door neighbors. Individuals must, and can, now ask, Where do *I* fit into the global competition and opportunities of the day, and how can *I*, on my own, collaborate with others globally?

But Globalization 3.0 not only differs from the previous eras in how it is shrinking and flattening the world and in how it is empowering indi-

viduals. It is different in that Globalization 1.0 and 2.0 were driven primarily by European and American individuals and businesses. Even though China actually had the biggest economy in the world in the eighteenth century, it was Western countries, companies, and explorers who were doing most of the globalizing and shaping of the system. But going forward, this will be less and less true. Because it is flattening and shrinking the world, Globalization 3.0 is going to be more and more driven not only by individuals but also by a much more diverse—non-Western, non-white—group of individuals. Individuals from every corner of the flat world are being empowered. Globalization 3.0 makes it possible for so many more people to plug and play, and you are going to see every color of the human rainbow take part.

(While this empowerment of individuals to act globally is the most important new feature of Globalization 3.0, companies—large and small—have been newly empowered in this era as well. I discuss both in detail later in the book.)

Needless to say, I had only the vaguest appreciation of all this as I left Nandan's office that day in Bangalore. But as I sat contemplating these changes on the balcony of my hotel room that evening, I did know one thing: I wanted to drop everything and write a book that would enable me to understand how this flattening process happened and what its implications might be for countries, companies, and individuals. So I picked up the phone and called my wife, Ann, and told her, "I am going to write a book called *The World Is Flat.*" She was both amused and curious—well, maybe *more* amused than curious! Eventually, I was able to bring her around, and I hope I will be able to do the same with you, dear reader. Let me start by taking you back to the beginning of my journey to India, and other points east, and share with you some of the encounters that led me to conclude the world was no longer round—but flat.

Jaithirth "Jerry" Rao was one of the first people I met in Bangalore—and I hadn't been with him for more than a few minutes at the Leela Palace hotel before he told me that he could handle my tax returns and any other accounting needs I had—from Bangalore. No thanks, I de-

SIX

The Untouchables

So if the flattening of the world is largely (but not entirely) unstoppable, and holds out the potential to be as beneficial to American society as a whole as past market evolutions have been, how does an individual get the best out of it? What do we tell our kids?

There is only one message: You have to constantly upgrade your skills. There will be plenty of good jobs out there in the flat world for people with the knowledge and ideas to seize them.

I am not suggesting this will be simple. It will not be. There will be a lot of other people out there also trying to get smarter. It was never good to be mediocre in your job, but in a world of walls, mediocrity could still earn you a decent wage. In a flatter world, you *really* do not want to be mediocre. You don't want to find yourself in the shoes of Willy Loman in *Death of a Salesman*, when his son Biff dispels his idea that the Loman family is special by declaring, "Pop! I'm a dime a dozen, and so are you!" An angry Willy retorts, "I am not a dime a dozen! I am Willy Loman, and you are Biff Loman!"

I don't care to have that conversation with my girls, so my advice to them in this flat world is very brief and very blunt: "Girls, when I was growing up, my parents used to say to me, 'Tom, finish your dinner—people in China and India are starving.' My advice to you is: Girls, finish your homework—people in China and India are starving for your jobs."

The way I like to think about this for our society as a whole is that every person should figure out how to make himself or herself into an untouchable. That's right. When the world goes flat, the caste system

gets turned upside down. In India untouchables may be the lowest social class, but in a flat world everyone should want to be an untouchable. Untouchables, in my lexicon, *are people whose jobs cannot be outsourced.*

So who are the untouchables, and how do you or your kids get to be one? Untouchables come in four broad categories: workers who are "special," workers who are "specialized," workers who are "anchored," and workers who are "really adaptable."

Workers who are special are people like Michael Jordan, Bill Gates, and Barbra Streisand. They have a global market for their goods and services and can command global-sized pay packages. Their jobs can never be outsourced.

If you can't be special—and only a few people can be—you want to be specialized, so that your work cannot be outsourced. This applies to all sorts of knowledge workers—from specialized lawyers, accountants, and brain surgeons, to cutting-edge computer architects and software engineers, to advanced machine tool and robot operators. These are skills that are always in high demand and are not fungible. ("Fungible" is an important word to remember. As Infosys CEO Nandan Nilekani likes to say, in a flat world there is "fungible and nonfungible work." Work that can be easily digitized and transferred to lower-wage locations is fungible. Work that cannot be digitized or easily substituted is nonfungible. Michael Jordan's jump shot is nonfungible. A bypass surgeon's technique is nonfungible. A television assembly-line worker's job is now fungible. Basic accounting and tax preparation are now fungible.)

If you cannot be special or specialized, you want to be anchored. That status applies to most Americans, everyone from my barber, to the waitress at lunch, to the chefs in the kitchen, to the plumber, to nurses, to many doctors, many lawyers, entertainers, electricians, and cleaning ladies. Their jobs are simply anchored and always will be, because they must be done in a specific location, involving face-to-face contact with a customer, client, patient, or audience. These jobs generally cannot be digitized and are not fungible, and the market wage is set according to the local market conditions. But be advised: There are fungible parts of even anchored jobs, and they can and will be outsourced—either to

India or to the past—for greater efficiency. (Yes, as David Rothkopf notes, more jobs are actually "outsourced to the past," thanks to new innovations, than are outsourced to India.) For instance, you are not going to go to Bangalore to find an internist or a divorce lawyer, but your divorce lawyer may one day use a legal aide in Bangalore for basic research or to write up vanilla legal documents, and your internist may use a nighthawk radiologist in Bangalore to read your CAT scan.

This is why if you cannot be special or specialized, you don't want to count on being anchored so you won't be outsourced. You actually want to become really adaptable. You want constantly to acquire new skills, knowledge, and expertise that enable you constantly to be able to create value—something more than vanilla ice cream. You want to learn how to make the latest chocolate sauce, the whipped cream, or the cherries on top, or to deliver it as a belly dancer—in whatever your field of endeavor. As parts of your work become commoditized and fungible, or turned into vanilla, adaptable people will always learn how to make some other part of the sundae. Being adaptable in a flat world, knowing how to "learn how to learn," will be one of the most important assets any worker can have, because job churn will come faster, because innovation will happen faster.

Atul Vashistha, CEO of NeoIT, a California consulting firm that specializes in helping U.S. firms do outsourcing, has a good feel for this: "What you can do and how you can adapt and how you can leverage all the experience and knowledge you have when the world goes flat—that is the basic component [for survival]. When you are changing jobs a lot, and when your job environment is changing a lot, being adaptable is the number one thing. The people who are losing out are those with solid technical skills who have not grown those skills. You have to be skillfully adaptable and socially adaptable."

The more we push out the boundaries of knowledge and technology, the more complex tasks that machines can do, the more those with specialized education, or the ability to learn how to learn, will be in demand, and for better pay. And the more those without that ability will be less generously compensated. What you don't want to be is a not very special, not very specialized, not very anchored, or not very adaptable

person in a fungible job. If you are in the low-margin, fungible end of the work food chain, where businesses have an incentive to outsource to lower-cost, equally efficient producers, there is a much greater chance that your job will be outsourced or your wages depressed.

"If you are a Web programmer and are still using only HTML and have not expanded your skill set to include newer and creative technologies, such as XML and multimedia, your value to the organization gets diminished every year," added Vashistha. New technologies get introduced that increase complexity but improve results, and as long as a programmer embraces these and keeps abreast of what clients are looking for, his or her job gets hard to outsource. "While technology advances make last year's work a commodity," said Vashistha, "reskilling, continual professional education and client intimacy to develop new relationships keeps him or her ahead of the commodity curve and away from a potential offshore."

My childhood friend Bill Greer is a good example of a person who faced this challenge and came up with a personal strategy to meet it. Greer is forty-eight years old and has made his living as a freelance artist and graphic designer for twenty-six years. From the late 1970s until right around 2000, the way Bill did his job and served his clients was pretty much the same.

"Clients, like *The New York Times*, would want a finished piece of artwork," Bill explained to me. So if he was doing an illustration for a newspaper or a magazine, or proposing a new logo for a product, he would actually create a piece of art—sketch it, color it, mount it on an illustration board, cover it with tissue, put it in a package that was opened with two flaps, and have it delivered by messenger or FedEx. He called it "flap art." In the industry it was known as "camera-ready art," because it needed to be shot, printed on four different layers of color film, or "separations," and prepared for publication. "It was a finished product, and it had a certain preciousness to it," said Bill. "It was a real piece of art, and sometimes people would hang them on their walls. In fact, *The New York Times* would have shows of works that were created by illustrators for its publications."

But in the last few years "that started to change," Bill told me, as publications and ad agencies moved to digital preparation, relying on the new software—namely, Quark, Photoshop, and Illustrator, which graphic artists refer to as "the trinity"—which made digital computer design so much easier. Everyone who went through art school got trained on these programs. Indeed, Bill explained, graphic design got so much easier that it became a commodity. It got turned into vanilla ice cream. "In terms of design," he said, "the technology gave everyone the same tools, so everyone could do straight lines and everyone could do work that was halfway decent. You used to need an eye to see if something was in balance and had the right typeface, but all of a sudden anyone could hammer out something that was acceptable."

So Greer pushed himself up the knowledge ladder. As publications demanded that all final products be presented as digital files that could be uploaded, and there was no longer any more demand for that precious flap art, he transformed himself into an ideas consultant. "Ideation" was what his clients, including McDonald's and Unilever, wanted. He stopped using pens and ink and would just do pencil sketches, scan them into his computer, color them by using the computer's mouse, and then e-mail them to the client, which would have some less skilled artists finish them.

"It was unconscious," said Greer. "I had to look for work that not everyone else could do, and that young artists couldn't do with technology for a fraction of what I was being paid. So I started getting offers where people would say to me, 'Can you do this and just give us the big idea?' They would give me a concept, and they would just want sketches, ideas, and not a finished piece of art. I still use the basic skill of drawing, but just to convey an idea—quick sketches, not finished artwork. And for these ideas they will still pay pretty good money. It has actually taken me to a different level. It is more like being a consultant rather than a JAFA (Just Another Fucking Artist). There are a lot of JAFAs out there. So now I am an idea man, and I have played off that. My clients just buy concepts." The JAFAs then do the art in-house or it gets outsourced. "They can take my raw sketches and finish them and illustrate them using com-

puter programs, and it is not like I would do it, but it is good enough," Greer said.

But then another thing happened. While the evolving technology turned the lower end of Greer's business into a commodity, it opened up a whole new market at the upper end: Greer's magazine clients. One day, one of his regular clients approached him and asked if he could do morphs. Morphs are cartoon strips in which one character evolves into another. So Martha Stewart is in the opening frame and morphs into Courtney Love by the closing frame. Drew Barrymore morphs into Drew Carey. Mariah Carey morphs into Jim Carrey. Cher morphs into Britney Spears. When he was first approached to do these, Greer had no idea where to begin. So he went onto Amazon.com and located some specialized software, bought it, tried it out for a few days, and produced his first morph. Since then he has developed a specialty in the process, and the market for them has expanded to include *Maxim* magazine, *More*, and *Nickelodeon*—one a men's magazine, one a middle-aged women's magazine, and one a kids' magazine.

In other words, someone invented a whole new kind of sauce to go on the vanilla, and Greer jumped on it. This is exactly what happens in the global economy as a whole. "I was experienced enough to pick these [morphs] up pretty quickly," said Greer. "Now I do them on my Mac laptop, anywhere I am, from Santa Barbara to Minneapolis to my apartment in New York. Sometimes clients give me a subject, and sometimes I just come up with them. Morphing used to be one of those really high-end things you saw on TV, and then they came out with this consumer [software] program and people could do it themselves, and I shaped them so magazines could use them. I just upload them as a series of JPEG files . . . Morphs have been a good business for different magazines. I even get fan mail from kids!"

Greer had never done morphs until the technology evolved and created a new, specialized niche, just when a changing market for his work made him eager to learn new skills. "I wish I could say it was all intentional," he confessed. "I was just available for work and just lucky they gave me a chance to do these things. I know so many artists who got

washed out. One guy who was an illustrator has become a package designer, some have gotten out of the field altogether; one of the best designers I know became a landscape architect. She is still a designer but changed her medium altogether. Visual people can adapt, but I am still nervous about the future."

I told Greer his story fit well into some of the terms I was using in this book. He began as a chocolate sauce (a classic illustrator), was turned into a vanilla commodity (a classic illustrator in the computer age), upgraded his skills to become a special chocolate sauce again (a design consultant), then learned how to become a cherry on top (a morphs artist) by fulfilling a new demand created by an increasingly specialized market.

Greer contemplated my compliment for a moment and then said, "And here all I was trying to do was survive—and I still am." As he got up to leave, though, he told me that he was going out to meet a friend "to juggle together." They have been juggling partners for years, just a little side business they sometimes do on a street corner or for private parties. Greer has very good hand-eye coordination. "But even juggling is being commoditized," he complained. "It used to be if you could juggle five balls, you were really special. Now juggling five balls is like just anteing up. My partner and I used to perform together, and he was the seven-ball champ when I met him. Now fourteen-year-old kids can juggle seven balls, no problem. Now they have these books, like *Juggling for Dummies*, and kits that will teach you how to juggle. So they've just upped the standard."

As goes juggling, so goes the world.

These are our real choices: to try to put up walls of protection or to keep marching forward with the confidence that American society still has the right stuff, even in a flatter world. I say march forward. As long as we keep tending to the secrets of our sauce, we will do fine. There are so many things about the American system that are ideally suited for nurturing individuals who can compete and thrive in a flat world.

How so? It starts with America's research universities, which spin off

a steady stream of competitive experiments, innovations, and scientific breakthroughs—from mathematics to biology to physics to chemistry. It is a truism, but the more educated you are, the more options you will have in a flat world. "Our university system is the best," said Bill Gates. "We fund our universities to do a lot of research and that is an amazing thing. High-IQ people come here, and we allow them to innovate and turn [their innovations] into products. We reward risk taking. Our university system is competitive and experimental. They can try out different approaches. There are one hundred universities making contributions to robotics. And each one is saying that the other is doing it all wrong, or my piece actually fits together with theirs. It is a chaotic system, but it is a great engine of innovation in the world, and with federal tax money, with some philanthropy on top of that, [it will continue to flourish] . . . We will really have to screw things up for our absolute wealth not to increase. If we are smart, we can increase it faster by embracing this stuff."

The Web browser, magnetic resonance imaging (MRI), superfast computers, global position technology, space exploration devices, and fiber optics are just a few of the many inventions that got started through basic university research projects. The BankBoston Economics Department did a study titled "MIT: The Impact of Innovation." Among its conclusions was that MIT graduates have founded 4,000 companies, creating at least 1.1 million jobs worldwide and generating sales of $232 billion.

What makes America unique is not that it built MIT, or that its grads are generating economic growth and innovation, but that every state in the country has universities trying to do the same. "America has 4,000 colleges and universities," said Allan E. Goodman, president of the Institute of International Education. "The rest of the world combined has 7,768 institutions of higher education. In the state of California alone, there are about 130 colleges and universities. There are only 14 countries in the world that have more than that number."

Take a state you normally wouldn't think of in this regard: Oklahoma. It has its own Oklahoma Center for the Advancement of Science and Technology (OCAST), which, on its Web site, describes its mission as follows: "In order to compete effectively in the new economy, Oklahoma

must continue to develop a well-educated population; a collaborative, focused university research and technology base; and a nurturing environment for cutting-edge businesses, from the smallest start-up to the largest international headquarters . . . [OCAST promotes] University-Business technology centers, which may span several schools and businesses, resulting in new businesses being spawned, new products being manufactured, and new manufacturing technologies employed." No wonder that in 2003, American universities reaped $1.3 billion from patents, according to the Association of University Technology Managers.

Coupled with America's unique innovation-generating machines—universities, public and private research labs, and retailers—we have the best-regulated and most efficient capital markets in the world for taking new ideas and turning them into products and services. Dick Foster, director of McKinsey & Co. and the author of two books on innovation, remarked to me, "We have an 'industrial policy' in the U.S.—it is called the stock exchange, whether it is the NYSE or the Nasdaq." That is where risk capital is collected and assigned to emerging ideas or growing companies, Foster said, and no capital market in the world does that better and more efficiently than the American one.

What makes capital provision work so well here is the security and regulation of our capital markets, where minority shareholders are protected. Lord knows, there are scams, excesses, and corruption in our capital markets. That always happens when a lot of money is at stake. What distinguishes our capital markets is not that Enrons don't happen in America—they sure do. It is that when they happen, they usually get exposed, either by the Securities and Exchange Commission or by the business press, and get corrected. What makes America unique is not Enron but Eliot Spitzer, the attorney general of New York State, who has doggedly sought to clean up the securities industry and corporate boardrooms. This sort of capital market has proved very, very difficult to duplicate outside of New York, London, Frankfurt, and Tokyo. Said Foster, "China and India and other Asian countries will not be successful at innovation until they have successful capital markets, and they will not have successful capital markets until they have rule of law which protects

minority interests under conditions of risk . . . We in the U.S. are the lucky beneficiaries of centuries of economic experimentation, and we are the experiment that has worked."

While these are the core secrets of America's sauce, there are others that need to be preserved and nurtured. Sometimes you have to talk to outsiders to appreciate them, such as Indian-born Vivek Paul of Wipro. "I would add three to your list," he said to me. "One is the sheer openness of American society." We Americans often forget what an incredibly open, say-anything-do-anything-start-anything-go-bankrupt-and-start-anything-again society the United States is. There is no place like it in the world, and our openness is a huge asset and attraction to foreigners, many of whom come from countries where the sky is not the limit.

Another, said Paul, is the "quality of American intellectual property protection," which further enhances and encourages people to come up with new ideas. In a flat world, there is a great incentive to develop a new product or process, because it can achieve global scale in a flash. But if you are the person who comes up with that new idea, you want your intellectual property protected. "No country respects and protects intellectual property better than America," said Paul, and as a result, a lot of innovators want to come here to work and lodge their intellectual property.

The United States also has among the most flexible labor laws in the world. The easier it is to fire someone in a dying industry, the easier it is to hire someone in a rising industry that no one knew would exist five years earlier. This is a great asset, especially when you compare the situation in the United States to inflexible, rigidly regulated labor markets like Germany's, full of government restrictions on hiring and firing. Flexibility to quickly deploy labor and capital where the greatest opportunity exists, and the ability to quickly redeploy it if the earlier deployment is no longer profitable, is essential in a flattening world.

Still another secret to America's sauce is the fact that it has the world's largest domestic consumer market, with the most first adopters, in the world, which means that if you are introducing a new product, technology, or service, you have to have a presence in America. All this means a steady flow of jobs for Americans.

There is also the little-discussed American attribute of political stability. Yes, China has had a good run for the past twenty-five years, and it may make the transition from communism to a more pluralistic system without the wheels coming off. But it may not. Who would want all his or her eggs in that basket?

Finally, the United States has become one of the great meeting points in the world, a place where lots of different people bond and learn to trust one another. An Indian student who is educated at the University of Oklahoma and then gets his first job with a software firm in Oklahoma City forges bonds of trust and understanding that are really important for future collaboration, even if he winds up returning to India. Nothing illustrates this point better than Yale University's outsourcing of research to China. Yale president Richard C. Levin explained to me that Yale has two big research operations running in China today, one at Peking University in Beijing and the other at Fudan University in Shanghai. "Most of these institutional collaborations arise not from top-down directives of university administrators, but rather from long-standing personal relationships among scholars and scientists," said Levin.

How did the Yale-Fudan collaboration arise? To begin with, said Levin, Yale professor Tian Xu, its director, had a deep affiliation with both institutions. He did his undergraduate work at Fudan and received his Ph.D. from Yale. "Five of Professor Xu's collaborators, who are now professors at Fudan, were also trained at Yale," explained Levin. One was Professor Xu's friend when both were Yale graduate students; another was a visiting scholar in the laboratory of a Yale colleague; one was an exchange student who came to Yale from Fudan and returned to earn his Ph.D. in China; and the other two were postdoctoral fellows in Professor Xu's Yale lab. A similar story underlies the formation of the Peking-Yale Joint Center for Plant Molecular Genetics and Agrobiotechnology.

Professor Xu is a leading expert on genetics and has won grants from the National Institutes of Health and the Howard Hughes Foundation to study the connection between genetics and cancer and certain neurodegenerative diseases. This kind of research requires the study of large numbers of genetic mutations in lab animals. "When you want to test many genes and trace for a given gene that may be responsible for cer-

tain diseases, you need to run a lot of tests. Having a bigger staff is a huge advantage," explained Levin. So what Yale did was essentially outsource the lab work to Fudan by creating the Fudan-Yale Biomedical Research Center. Each university pays for its own staff and research, so no money changes hands, but the Chinese side does the basic technical work using large numbers of technicians and lab animals, which cost so much less in China, and Yale does the high-end analysis of the data. The Fudan staff, students, and technicians get great exposure to high-end research, and Yale gets a large-scale testing facility that would have been prohibitively expensive if Yale had tried to duplicate it in New Haven. A support lab in America for a project like this one might have 30 technicians, but the one in Fudan has 150.

"The gains are very much two-way," said Levin. "Our investigators get substantially enhanced productivity, and the Chinese get their graduate students trained, and their young faculty become collaborators with our professors, who are the leaders in their fields. It builds human capital for China and innovation for Yale." Graduate students from both universities go back and forth, forging relationships that will no doubt produce more collaborations in the future. At the same time, he added, a lot of legal preparation went into this collaboration to make sure that Yale would be able to harvest the intellectual property that is created.

"There is one world of science out there," said Levin, "and this kind of international division of labor makes a lot of sense." Yale, he said, also insisted that the working conditions at the Chinese labs be world-class, and, as a result, it has also helped to lift the quality of the Chinese facilities. "The living conditions of the lab animals are right up to U.S. standards," remarked Levin. "These are not mouse sweatshops."

Every law of economics tells us that if we connect all the knowledge pools in the world, and promote greater and greater trade and integration, the global pie will grow wider and more complex. And if America, or any other country, nurtures a labor force that is increasingly made up of men and women who are special, specialized, or constantly adapting to higher-value-added jobs, it will grab its slice of that growing pie. But

we will have to work at it. Because if current trends prevail, countries like India and China and whole regions like Eastern Europe are certain to narrow the gap with America, just as Korea and Japan and Taiwan did during the Cold War. They will keep upping their standards.

So are we still working at it? Are we tending to the secrets of our sauce? America still looks great on paper, especially if you look backward, or compare it only to India and China of today and not tomorrow. But have we really been investing in our future and preparing our children the way we need to for the race ahead? See the next chapter. But here's a quick hint:

The answer is no.

SEVEN

The Quiet Crisis

Close games for the Americans were rare in previous Olympics, but now it appears to be something the Americans should get used to.

—From an August 17, 2004, AP article from the Athens Olympics titled "U.S. Men's Basketball Team Narrowly Beats Greece"

You could find no better metaphor for the way the rest of the world can now compete head-to-head more effectively than ever with America than the struggles of the U.S. Olympic basketball team in 2004. The American team, made up of NBA stars, limped home to a bronze medal after losing to Puerto Rico, Lithuania, and Argentina. Previously, the United States Olympic basketball team had lost only one game in the history of the modern Olympics. Remember when America sent only NCAA stars to the Olympic basketball events? For a long time these teams totally dominated all comers. Then they started getting challenged. So we sent our pros. And they started getting challenged. Because the world keeps learning, the diffusion of knowledge happens faster; coaches in other countries now download American coaching methods off the Internet and watch NBA games in their own living rooms on satellite TV. Many of them can even get ESPN and watch the highlight reels. And thanks to the triple convergence, there is a lot of new raw talent walking onto the NBA courts from all over the world—including many new stars from China, Latin America, and Eastern Europe. They go back and play for their national teams in the Olympics, using the skills they honed

in America. So the automatic American superiority of twenty years ago is now gone in Olympic basketball. The NBA standard is increasingly becoming a global commodity—pure vanilla. If the United States wants to continue to dominate in Olympic basketball, we must, in that great sports cliché, step it up a notch. The old standard won't do anymore. As Joel Cawley of IBM remarked to me, "Star for star, the basketball teams from places like Lithuania or Puerto Rico still don't rank well versus the Americans, but when they play as a team—when they *collaborate* better than we do—they are extremely competitive."

Sports writer John Feinstein could have been referring to either American engineering skills or American basketball skills when he wrote in an August 26, 2004, AOL essay on Olympic basketball that the performance of the U.S. basketball team is a result of "the rise of the international player" and "the decline and fall of the U.S. game." And the decline and fall of the U.S. game, argued Feinstein, is a result of two long-term trends. The first is a steady decline "in basketball skills," with American kids just wanting to shoot either three-point shots or dunk—the sort of stuff that gets you on ESPN's *SportsCenter* highlight reel—instead of learning how to make precise passes, or go into the lane and shoot a pull-up jumper, or snake through big men to get to the basket. Those skills take a lot of hard work and coaching to learn. Today, said Feinstein, you have an American generation that relies almost completely on athleticism and almost not at all on basketball skills. And there is also that ugly little problem of ambition. While the rest of the world was getting better in basketball, "more and more NBA players were yawning at the notion of playing in the Olympics," noted Feinstein. "We have come a long way from 1984, when Bob Knight told Charles Barkley to show up to the second Olympic training camp at 265 pounds or else. Barkley showed up weighing 280. Knight cut him that day. In today's world, the Olympic coach wouldn't even have checked Barkley's weight in the first place. He would have sent a limousine to the airport to get him and stopped at Dunkin' Donuts on the way to the hotel if the player requested it . . . The world changes. In the case of American basketball, it hasn't changed for the better."

There is something about post–World War II America that reminds

me of the classic wealthy family that by the third generation starts to squander its wealth. The members of the first generation are nose-to-the-grindstone innovators; the second generation holds it all together; then their kids come along and get fat, dumb, and lazy and slowly squander it all. I know that is both overly harsh and a gross generalization, but there is, nevertheless, some truth in it. American society started to coast in the 1990s, when our third postwar generation came of age. The dot-com boom left too many people with the impression that they could get rich without investing in hard work. All it took was an MBA and a quick IPO, or one NBA contract, and you were set for life. But while we were admiring the flat world we had created, a lot of people in India, China, and Eastern Europe were busy figuring out how to take advantage of it. Lucky for us, we were the only economy standing after World War II, and we had no serious competition for forty years. That gave us a huge head of steam but also a huge sense of entitlement and complacency—not to mention a certain tendency in recent years to extol consumption over hard work, investment, and long-term thinking. When we got hit with 9/11, it was a once-in-a-generation opportunity to summon the nation to sacrifice, to address some of its pressing fiscal, energy, science, and education shortfalls—all the things that we had let slide. But our president did not summon us to sacrifice. He summoned us to go shopping.

In the previous chapters, I showed why both classic economic theory and the inherent strengths of the American economy have convinced me that American individuals have nothing to worry about from a flat world—provided we roll up our sleeves, be ready to compete, get every individual to think about how he or she upgrades his or her educational skills, and keep investing in the secrets of the American sauce. Those chapters were all about what we must do and can do.

This chapter is about how we Americans, individually and collectively, have not been doing all these things that we should be doing and what will happen down the road if we don't change course.

The truth is, we are in a crisis now, but it is a crisis that is unfolding very slowly and very quietly. It is "a quiet crisis," explained Shirley

Ann Jackson, the 2004 president of the American Association for the Advancement of Science and president of Rensselaer Polytechnic Institute since 1999. (Rensselaer is America's oldest technological college, founded in 1824.) And this quiet crisis involves the steady erosion of America's scientific and engineering base, which has always been the source of American innovation and our rising standard of living.

"The sky is not falling, nothing horrible is going to happen today," said Jackson, a physicist by training who chooses her words carefully. "The U.S. is still the leading engine for innovation in the world. It has the best graduate programs, the best scientific infrastructure, and the capital markets to exploit it. But there is a quiet crisis in U.S. science and technology that we have to wake up to. The U.S. today is in a truly global environment, and those competitor countries are not only wide awake, they are running a marathon while we are running sprints. If left unchecked, this could challenge our preeminence and capacity to innovate."

And it is our ability to constantly innovate new products, services, and companies that has been the source of America's horn of plenty and steadily widening middle class for the last two centuries. It was American innovators who started Google, Intel, HP, Dell, Microsoft, and Cisco, and it matters where innovation happens. The fact that all these companies are headquartered in America means that most of the high-paying jobs are here, even if these companies outsource or offshore some functions. The executives, the department heads, the sales force, and the senior researchers are all located in the cities where the innovation happened. And their jobs create more jobs. The shrinking of the pool of young people with the knowledge skills to innovate won't shrink our standard of living overnight. It will be felt only in fifteen or twenty years, when we discover we have a critical shortage of scientists and engineers capable of doing innovation or even just high-value-added technology work. Then this won't be a quiet crisis anymore, said Jackson, "it will be the real McCoy."

Shirley Ann Jackson knows of what she speaks, because her career exemplifies as well as anyone's both why America thrived so much in the past fifty years and why it won't automatically do the same in the next

fifty. An African-American woman, Jackson was born in Washington, D.C., in 1946. She started kindergarten in a segregated public school but was one of the first public school students to benefit from desegregation, as a result of the Supreme Court ruling in *Brown v. Board of Education*. Just when she was getting a chance to go to a better school, the Russians launched Sputnik in 1957, and the U.S. government became obsessed with educating young people to become scientists and engineers, a trend that was intensified by John F. Kennedy's commitment to a manned space program. When Kennedy spoke about putting a man on the moon, Shirley Ann Jackson was one of the millions of American young people who were listening. His words, she recalled, "inspired, assisted, and launched many of my generation into science, engineering and mathematics," and the breakthroughs and inventions they spawned went well beyond the space program. "The space race was really a science race," she said.

Thanks in part to desegregation, both Jackson's inspiration and intellect were recognized early, and she ultimately became the first African-American woman to earn a Ph.D. in physics from MIT (her degree was in theoretical elementary particle physics). From there, she spent many years working for AT&T Bell Laboratories, and in 1995 was appointed by President Clinton to chair the U.S. Nuclear Regulatory Commission.

As the years went by, though, Jackson began to notice that fewer and fewer young Americans were captivated by national challenges like the race to the moon, or felt the allure of math, science, and engineering. In universities, she noted, graduate enrollment in science and engineering programs, having grown for decades, peaked in 1993, and despite some recent progress, it remains today below the level of a decade ago. So the science and engineering generations that followed Jackson's got smaller and smaller relative to our needs. By the time Jackson took the job as Rensselaer Polytechnic's president to put her heart and soul into reinvigorating American science and engineering, she realized, she said, that a "perfect storm" was brewing—one that posed a real long-term danger to America's economic health—and she started speaking out about it whenever she could.

"The phrase 'the perfect storm' is associated with meteorological events in October 1991," said Jackson in a speech in May 2004, when "a powerful weather system gathered force, ravaging the Atlantic Ocean over the course of several days, [and] caused the deaths of several Massachusetts-based fishermen and billions of dollars of damage. The event became a book, and, later, a movie. Meteorologists observing the event emphasized . . . the unlikely confluence of conditions . . . in which multiple factors converged to bring about an event of devastating magnitude. [A] similar worst-case scenario could arrest the progress of our national scientific and technological capacity. The forces at work are multiple and complex. They are demographic, political, economic, cultural, even social." Individually, each of these forces would be problematic, added Jackson. In combination, they could be devastating. "For the first time in more than a century, the United States could well find itself falling behind other countries in the capacity for scientific discovery, innovation and economic development."

The way to avoid being caught in such a storm is to identify the confluence of factors and to change course—even though right now the sky is blue, the winds are gentle, and the water seems calm. But that is not what has been going on in America in recent years. We are blithely sailing along, heading straight for the storm, with both politicians and parents insisting that no dramatic changes or sacrifices are required now. After all, look how calm and sunny it is outside, they tell us. In the fiscal year 2005 budget passed by the Republican-led Congress in November 2004, the budget for the National Science Foundation, which is the federal body most responsible for promoting research and funding more and better science education, was actually cut by 1.9 percent, or $105 million. History will show that when America should have been doubling the NSF funding, its Congress passed a pork-laden budget that actually cut assistance for science and engineering.

Don't be fooled by the calm. That's always the time to change course—not when you're just about to get hit by the typhoon. We don't have any time to waste in addressing the "dirty little secrets" of our education system.

Dirty Little Secret #1: The Numbers Gap

In the Cold War, one of the deepest causes of American worries was the so-called missile gap between us and the Soviet Union. The perfect storm Shirley Ann Jackson is warning about could best be described as the confluence of three new gaps that have been slowly emerging to sap America's prowess in science, math, and engineering. They are the numbers gap, the ambition gap, and the education gap. In the Age of Flatism, these gaps are what most threaten our standard of living.

Dirty little secret number one is that the generation of scientists and engineers who were motivated to go into science by the threat of Sputnik in 1957 and the inspiration of JFK are reaching their retirement years and are not being replaced in the numbers that they must be if an advanced economy like that of the United States is to remain at the head of the pack. According to the National Science Foundation, half of America's scientists and engineers are forty years or older, and the average age is steadily rising.

Just take one example—NASA. An analysis of NASA records conducted by the newspaper *Florida Today* (March 7, 2004), which covers the Kennedy Space Center, showed the following: Nearly 40 percent of the 18,146 people at NASA are age fifty or older. Those with twenty years of government service are eligible for early retirement. Twenty-two percent of NASA workers are fifty-five or older. NASA employees over sixty outnumber those under thirty by a ratio of about three to one. Only 4 percent of NASA workers are under thirty. A 2003 Government Accounting Office study concluded that NASA was having difficulty hiring people with the sufficient science, engineering, and information-technology skills that are critical to its operations. Many of these jobs are reserved for American citizens, because of national security concerns. Then–NASA administrator Sean O'Keefe testified before Congress in 2002: "Our mission of understanding and protecting our home planet and exploring the universe and searching for life will not be carried out if we don't have the people to do it." The National Commission on Mathematics and Science Teaching for the Twenty-first Century, chaired by the former astronaut and senator John Glenn, found that two-

thirds of the nation's mathematics and science teaching force will retire by 2010.

Traditionally we made up for any shortages of engineers and science faculty by educating more at home and importing more from abroad. But both of those remedies have been stalled of late.

Every two years the National Science Board supervises the collection of a very broad set of data trends in science and technology in the United States, which it publishes as *Science and Engineering Indicators*. In preparing *Indicators* 2004, the NSB said, "We have observed a troubling decline in the number of U.S. citizens who are training to become scientists and engineers, whereas the number of jobs requiring science and engineering (S&E) training continues to grow." These trends threaten the economic welfare and security of our country, it said, adding that if the trends identified in *Indicators* 2004 continue undeterred, three things will happen: "The number of jobs in the U.S. economy that require science and engineering training will grow; the number of U.S. citizens prepared for those jobs will, at best, be level; and the availability of people from other countries who have science and engineering training will decline, either because of limits to entry imposed by U.S. national security restrictions or because of intense global competition for people with these skills."

The NSB report found that the number of American eighteen-to-twenty-four-year-olds who receive science degrees has fallen to seventeenth in the world, whereas we ranked third three decades ago. It said that of the 2.8 million first university degrees (what we call bachelor's degrees) in science and engineering granted worldwide in 2003, 1.2 million were earned by Asian students in Asian universities, 830,000 were granted in Europe, and 400,000 in the United States. In engineering specifically, universities in Asian countries now produce eight times as many bachelor's degrees as the United States.

Moreover, "the proportional emphasis on science and engineering is greater in other nations," noted Shirley Ann Jackson. Science and engineering degrees now represent 60 percent of all bachelor's degrees earned in China, 33 percent in South Korea, and 41 percent in Taiwan. By contrast, the percentage of those taking a bachelor's degree in science

and engineering in the United States remains at roughly 31 percent. Factoring out science degrees, the number of Americans who graduate with just engineering degrees is 5 percent, as compared to 25 percent in Russia and 46 percent in China, according to a 2004 report by Trilogy Publications, which represents the national U.S. engineering professional association.

The United States has always depended on the inventiveness of its people in order to compete in the world marketplace, said the NSB. "Preparation of the S&E workforce is a vital arena for national competitiveness. [But] even if action is taken today to change these trends, the reversal is 10 to 20 years away." The students entering the science and engineering workforce with advanced degrees in 2004 decided to take the necessary math courses to enable this career path when they were in middle school, up to fourteen years ago, the NSB noted. The students making that same decision in middle school today won't complete advanced training for science and engineering occupations until 2018 or 2020. "If action is not taken now to change these trends, we could reach 2020 and find that the ability of U.S. research and education institutions to regenerate has been damaged and that their preeminence has been lost to other areas of the world," the science board said.

These shortages could not be happening at a worse time—just when the world is going flat. "The number of jobs requiring science and engineering skills in the U.S. labor force," the NSB said, "is growing almost 5 percent per year. In comparison, the rest of the labor force is growing at just over 1 percent. Before September 11, 2001, the Bureau of Labor Statistics (BLS) projected that science and engineering occupations would increase at three times the rate of all occupations." Unfortunately, the NSB reported, the average age of the science and engineering workforce is rising.

"Many of those who entered the expanding S&E workforce in the 1960s and 1970s (the baby boom generation) are expected to retire in the next twenty years, and their children are not choosing science and engineering careers in the same numbers as their parents," the NSB report said. "The percentage of women, for example, choosing math and computer science careers fell 4 percentage points between 1993 and 1999."

The 2002 NSB indicators showed that the number of science and engineering Ph.D.'s awarded in the United States dropped from 29,000 in 1998 to 27,000 in 1999. The total number of engineering undergraduates in America fell about 12 percent between the mid-1980s and 1998.

Nevertheless, America's science and engineering labor force grew at a rate well above that of America's production of science and engineering degrees, because a large number of foreign-born S&E graduates migrated to the United States. The proportion of foreign-born students in S&E fields and workers in S&E occupations continued to rise steadily in the 1990s. The NSB said that persons born outside the United States accounted for 14 percent of all S&E occupations in 1990. Between 1990 and 2000, the proportion of foreign-born people with bachelor's degrees in S&E occupations rose from 11 to 17 percent; the proportion of foreign-born with master's degrees rose from 19 to 29 percent; and the proportion of foreign-born with Ph.D.'s in the S&E labor force rose from 24 to 38 percent. By attracting scientists and engineers born and trained in other countries we have maintained the growth of the S&E labor force without a commensurate increase in support for the long-term costs of training and attracting native U.S citizens to these fields, the NSB said.

But now, the simultaneous flattening and wiring of the world have made it much easier for foreigners to innovate without having to emigrate. They can now do world-class work for world-class companies at very decent wages without ever having to leave home. As Allan E. Goodman, president of the Institute of International Education, put it, "When the world was round, they could not go back home, because there was no lab to go back to and no Internet to connect to. But now all those things are there, so they are going back. Now they are saying, 'I feel more comfortable back home. I can live more comfortably back home than in New York City and I can do good work, so why not go back?'" This trend started even before the visa hassles brought on by 9/11, said Goodman. "The brain gain started to go to brain drain around the year 2000."

As the NSB study noted, "Since the 1980s other countries have increased investment in S&E education and the S&E workforce at higher rates than the United States has. Between 1993 and 1997, the OECD countries [Organization for Economic Co-operation and Development,

a group of 40 nations with highly developed market economies] increased their number of S&E research jobs 23 percent, more than twice the 11 percent increase in S&E research jobs in the United States."

In addition, it said, visas for students and S&E workers have been issued more slowly since the events of September 11, owing to both increased security restrictions and a drop in applications. The U.S. State Department issued 20 percent fewer visas for foreign students in 2001 than in 2000, and the rate fell farther in subsequent years. While university presidents told me in 2004 that the situation was getting better, and that the Department of Homeland Security was trying to both speed up and simplify its visa procedures for foreign students and scientists, a lot of damage has been done, and the situation for foreign students or scientists wanting to work in any areas deemed to have national security implications is becoming a real problem. No wonder *New York Times* education writer Sam Dillon reported on December 21, 2004, that "foreign applications to American graduate schools declined 28 percent this year. Actual foreign graduate student enrollments dropped 6 percent. Enrollments of all foreign students, in undergraduate, graduate and postdoctoral programs, fell for the first time in three decades in an annual census released this fall. Meanwhile, university enrollments have been surging in England, Germany and other countries . . . Chinese applications to American graduate schools fell 45 percent this year, while several European countries announced surges in Chinese enrollment."

Dirty Little Secret #2: The Ambition Gap

The second dirty little secret, which several prominent American CEOs told me only in a whisper, goes like this: When they send jobs abroad, they not only save 75 percent on wages, they get a 100 percent increase in productivity. Part of that is understandable. When you take a low-wage, low-prestige job in America, like a call center operator, and bring it over to India, where it becomes a high-wage, high-prestige job,

you end up with workers who are paid less but motivated more. "The dirty little secret is that not only is [outsourcing] cheaper and efficient," the American CEO of a London-headquartered multinational told me, "but the quality and productivity [boost] is huge." In addition to the wage compression, he said, one Bangalore Indian retrained will do the work of two or three Europeans, and the Bangalore employees don't take six weeks of holidays. "When you think it's only about wages," he added, "you can still hold your dignity, but the fact that they work better is awful."

A short time after returning from India, I was approached in an airport by a young man who wanted to talk about some columns I had written from there. We had a nice chat, I asked him for his card, and we struck up an e-mail friendship. His name is Mike Arguello, and he is an IT systems architect living in San Antonio. He does high-end IT systems design and does not feel threatened by foreign competition. He also teaches computer science. When I asked him what we needed to do in America to get our edge back, he sent me this e-mail:

> I taught at a local university. It was disheartening to see the poor work ethic of many of my students. Of the students I taught over six semesters, I'd only consider hiring two of them. The rest lacked the creativity, problem-solving abilities and passion for learning. As you well know, India's biggest advantage over the Chinese and Russians is that they speak English. But it would be wrong to assume the top Indian developers are better than their American counterparts. The advantage they have is the number of bodies they can throw at a problem. The Indians that I work with are the cream of the crop. They are educated by the equivalents of MIT back in India and there are plenty of them. If you were to follow me in my daily meetings it would become very obvious that a great deal of my time is spent working with Indians. Most managers are probably still under the impression that all Indians are doing is lower-end software development—"software assembly." But technologies, such as Linux, are allowing them to start taking higher-paying system design jobs that had previously

been the exclusive domain of American workers. It has provided them with the means to move up the technology food chain, putting them on par with domestic workers. It's brain power against brain power, and in this area they are formidable. From a technology perspective, the world is flat and getting flatter (if that is possible). The only two areas that I have not seen Indian labor in are networking architects and system architects, but it is only a matter of time. Indians are very bright and they are quickly learning from their interaction with system architects just how all of the pieces of the IT puzzle fit together . . . Were Congress to pass legislation to stop the flow of Indian labor, you would have major software systems that would have nobody who knew what was going on. It is unfortunate that many management positions in IT are filled with non-technical managers who may not be fully aware of their exposure . . . I'm an expert in information systems, not economics, but I know a high-paying job requires one be able to produce something of high value. The economy is producing the jobs both at the high end and low end, but increasingly the high-end jobs are out of reach of many. Low education means low-paying jobs, plain and simple, and this is where more and more Americans are finding themselves. Many Americans can't believe they aren't qualified for high-paying jobs. I call this the "*American Idol* problem." If you've ever seen the reaction of contestants when Simon Cowell tells them they have no talent, they look at him in total disbelief. I'm just hoping someday I'm not given such a rude awakening.

In the winter of 2004 I had tea in Tokyo with Richard C. Koo, chief economist for the Nomura Research Institute. I tested out on Richard my "coefficient of flatness": the notion that the flatter one's country is—that is, the fewer natural resources it has—the better off it will be in a flat world. The ideal country in a flat world is the one with *no natural resources*, because countries with no natural resources tend to dig inside themselves. They try to tap the energy, entrepreneurship, creativity, and intelligence of their own people—men and women—rather than drill

an oil well. Taiwan is a barren rock in a typhoon-laden sea, with virtually no natural resources—nothing but the energy, ambition, and talent of its own people—and today it has the third-largest financial reserves in the world. The success of Hong Kong, Japan, South Korea, and coastal China can all be traced to a similar flatness.

"I am a Taiwanese-American with a father from Taiwan and with a Japanese mother," Koo told me. "I was born in Japan and went to Japanese elementary school and then moved to the States. There is a saying in China that whatever you put in your head and your stomach, no one can take away from you. In this whole region, that is in the DNA. You just have to study hard and move forward. I was told relatively early by my teachers, 'We can never live like Americans and Canadians. We have no resources. We have to study hard, work hard, and export hard.'"

A few weeks later I had breakfast in Washington with P. V. Kannan, CEO of 24/7 Customer. When it comes to the flat world, said P.V., he had just one question: "Is America prepared? It is not . . . You've gotten a little contented and slow, and the people who came into the field with [the triple convergence] are really hungry. Immigrants are always hungry—and they don't have a backup plan."

A short time later I read a column by Steven Pearlstein, *The Washington Post*'s business columnist/reporter, under the headline "Europe's Capitalism Curtain." From Wroclaw, Poland (July 23, 2004), Pearlstein wrote: "A curtain has descended across Europe. On one side are hope, optimism, freedom and prospects for a better life. On the other side, fear, pessimism, suffocating government regulations and a sense that the best times are in the past." This new curtain, Pearlstein argued, demarks Eastern Europe, which is embracing capitalism, and Western Europe, which is wishing desperately that it would go away.

"This time, however, it is the East that is likely to prevail," he continued. "The energy and sense of possibility are almost palpable here . . . Money and companies are pouring in—not just the prestige nameplates like Bombardier, Siemens, Whirlpool, Toyota and Volvo, but also the network of suppliers that inevitably follows them. At first, most of the new jobs were of the semi-skilled variety. Now they have been followed by design and engineering work that aims to tap into the largest concen-

tration of university students in Eastern Europe . . . The secret isn't just lower wages. It's also the attitude of workers who take pride and are willing to do what is necessary to succeed, even if it means outsourcing parts production or working on weekends or altering vacation schedules—things that would almost certainly trigger months of acrimony and negotiation in Western Europe. 'The people back home, they haven't got any idea how much they need to change if they want to preserve what they have,' said Jose Ugarte [a Basque who heads the appliance manufacturing operations of Mondragon, the giant Spanish industrial cooperative]. 'The danger to them is enormous. They don't realize how fast this is happening . . .' It's not the dream of riches that animates the people of Wroclaw so much as the determination to work hard, sacrifice what needs to be sacrificed and change what needs to be changed to close the gap with the West. It is that pride and determination, says Wroclaw's mayor, Rafal Dutkiewicz, that explain why they are such a threat to the 'leisure-time society' on the other side of the curtain."

I heard a similar refrain in a discussion with consular officials who oversee the granting of visas at the U.S. embassy in Beijing. As one of them put it to me, "I do think Americans are oblivious to the huge changes. Every American who comes over to visit me [in China] is just blown away . . . Your average kid in the U.S. is growing up in a wealthy country with many opportunities, and many are the kids of advantaged educated people and have a sense of entitlement. Well, the hard reality for that kid is that fifteen years from now Wu is going to be his boss and Zhou is going to be the doctor in town. The competition is coming, and many of the kids are going to move into their twenties clueless about these rising forces."

When I asked Bill Gates about the supposed American education advantage—an education that stresses creativity, not rote learning—he was utterly dismissive. In his view, those who think that the more rote learning systems of China and Japan can't turn out innovators who can compete with Americans are sadly mistaken. Said Gates, "I have never met the guy who doesn't know how to multiply who created software . . . Who has the most creative video games in the world? Japan! I never met

these 'rote people' . . . Some of my best software developers are Japanese. You need to understand things in order to invent beyond them."

One cannot stress enough: Young Chinese, Indians, and Poles are not racing us to the bottom. They are racing us to the top. They do not want to work for us; they don't even want to be us. They want to dominate us—in the sense that they want to be creating the companies of the future that people all over the world will admire and clamor to work for. They are in no way content with where they have come so far. I was talking to a Chinese-American who works for Microsoft and has accompanied Bill Gates on visits to China. He said Gates is recognized everywhere he goes in China. Young people there hang from the rafters and scalp tickets just to hear him speak. Same with Jerry Yang, the founder of Yahoo!

In China today, Bill Gates is Britney Spears. In America today, Britney Spears is Britney Spears—and that is our problem.

Dirty Little Secret #3: The Education Gap

All of this helps to explain the third dirty little secret: A lot of the jobs that are starting to go abroad today are very high-end research jobs, because not only is the talent abroad cheaper, but a lot of it is as educated as American workers—or even more so. In China, where there are 1.3 billion people and the universities are just starting to crack the top ranks, the competition for top spots is ferocious. The math/science salmon that swims upstream in China and gets itself admitted to a top Chinese university or hired by a foreign company is one smart fish. The folks at Microsoft have a saying about their research center in Beijing, which, for scientists and engineers, is one of the most sought-after places to work in all of China. "Remember, in China when you are one in a million—there are 1,300 other people just like you."

The brainpower that rises to the Microsoft research center in Beijing is already one in a million.

Consider the annual worldwide Intel International Science and Engineering Fair. About forty countries participate by nominating talent through local affiliate affairs. In 2004, the Intel Fair attracted around sixty-five thousand American kids, according to Intel. How about in China? I asked Wee Theng Tan, the president of Intel China, during a visit to Beijing. In China, he told me, there is a national affiliate science fair, which acts as a feeder system to select kids for the global Intel fair. "Almost every single province has students going to one of these affiliate fairs," said Tan. "We have as many as six million kids competing, although not all are competing for the top levels . . . [But] you know how seriously they take it. Those selected to go to the international [Intel] fair are immediately exempted from college entrance exams" and basically get their choice of any top university in China. In the 2004 Intel Science Fair, China came home with thirty-five awards, more than any other country in Asia, including one of the top three global awards.

Microsoft has three research centers in the world: in Cambridge, England; in Redmond, Washington, its headquarters; and in Beijing. Bill Gates told me that within just a couple of years of its opening in 1998, Microsoft Research Asia, as the center in Beijing is known, had become the most productive research arm in the Microsoft system "in terms of the quality of the ideas that they are turning out. It is mind-blowing."

Kai-Fu Li is the Microsoft executive who was assigned by Gates to open the Microsoft research center in Beijing. My first question to him was, "How did you go about recruiting the staff?" Li said his team went to universities all over China and simply administered math, IQ, and programming tests to Ph.D.-level students or scientists.

"In the first year, we gave about 2,000 tests all around," he said. From the 2,000, they winnowed the group down to 400 with more tests, then 150, "and then we hired 20." They were given two-year contracts and told that at the end of two years, depending on the quality of their work, they would either be given a longer-term contract or granted a postdoctoral degree by Microsoft Research Asia. Yes, you read that right. The Chinese government gave Microsoft the right to grant postdocs. Of the original twenty who were hired, twelve survived the cut. The next year, nearly four thousand people were tested. After that, said Li, "we stopped

doing the test. By that time we became known as the number one place to work, where all the smart computer and math people wanted to work . . . We got to know all the students and professors. The professors would send their best people there, knowing that if the people did not work out, it would be their credibility [on the line]. Now we have the top professors at the top schools recommending their top students. A lot of students want to go to Stanford or MIT, but they want to spend two years at Microsoft first, as interns, so they can get a nice recommendation letter that says these are MIT quality." Today Microsoft has more than two hundred researchers in its China lab and some four hundred students who come in and out on projects and become recruiting material for Microsoft.

"They view this as a once-in-a-lifetime income opportunity," said Li of the team at Microsoft Research Asia. "They saw their parents going through the Cultural Revolution. The best they could do was become a professor, do a little project on the side because a professor's pay is horrible, and maybe get one paper published. Now they have this place where all they do is research, with great computers and lots of resources. They have administrators—we hire people to do the dirty work. They just could not believe it. They voluntarily work fifteen to eighteen hours a day and come in on weekends. They work through holidays, because their dream is to get to Microsoft." Li, who had worked for other American high-tech firms before coming to Microsoft, said that until starting Microsoft Research Asia, he had never seen a research lab with the enthusiasm of a start-up company.

"If you go in at two a.m. it is full, and at eight a.m. it is full," he said.

Microsoft is a stronger American company for being able to attract all this talent, said Li. "Now we have two hundred more brilliant people building [intellectual property] and patents. These two hundred people are not replacing people in Redmond. They are doing new research in areas applicable worldwide."

Microsoft Research Asia has already developed a worldwide reputation for producing cutting-edge papers for the most important scientific journals and conferences. "This is the culture that built the Great Wall," he added, "because it is a dedicated and direction-following culture."

Chinese people, explained Li, have both a superiority and an inferiority complex at the same time, which helps explain why they are racing America to the top, not the bottom. There is a deep and widely shared view that China was once great, that it succeeded in the past but now is far behind and must catch up again. "So there is a patriotic desire," he said. "If our lab can do as well as the Redmond lab, that could be really exciting."

That sort of inspired leadership in science and engineering education is now totally missing in the United States.

Said Intel chairman Craig Barrett, "U.S. technological leadership, innovation, and jobs of tomorrow require a commitment to basic research funding today." According to a 2004 study by the Task Force on the Future of American Innovation, an industry-academic coalition, basic research performed at leading U.S. universities—research in chemistry, physics, nanotechnology, genomics, and semiconductor manufacturing—has created four thousand spin-off companies that hired 1.1 million employees and have annual world sales of $232 billion. But to keep moving ahead, the study said, there must be a 10 to 12 percent increase each year for the next five to seven years in the budgets of key research-funding agencies: the National Institute for Science and Technology, the National Science Foundation, the Department of Energy's Office of Science, and the Department of Defense research accounts.

Unfortunately, federal funding for research in physical and mathematical sciences and engineering, as a share of GDP, actually declined by 37 percent between 1970 and 2004, the task force found. At a time when we need to be doubling our investments in basic research to overcome the ambition and education gaps, we are actually cutting that funding.

In the wake of the Bush administration and the Republican Congress's decision to cut the National Science Foundation funding for 2005, Republican congressman Vern Ehlers of Michigan, a voice in the wilderness, made the following statement: "While I understand the need to make hard choices in the face of fiscal constraint, I do not see the wisdom in putting science funding behind other priorities. We have cut NSF despite the fact that this omnibus bill increases spending for the

2005 fiscal year, so clearly we could find room to grow basic research while maintaining fiscal constraint. But not only are we not keeping pace with inflationary growth, we are actually cutting the portion basic research receives in the overall budget. This decision shows dangerous disregard for our nation's future, and I am both concerned and astonished that we would make this decision at a time when other nations continue to surpass our students in math and science and consistently increase their funding of basic research. We cannot hope to fight jobs lost to international competition without a well-trained and educated workforce."

No, we cannot, and the effects are starting to show. According to the National Science Board, the percentage of scientific papers written by Americans has fallen 10 percent since 1992. The percentage of American papers published in the top physics journal, *Physical Review*, has fallen from 61 percent to 29 percent since 1983. And now we are starting to see a surge in patents awarded to Asian countries. From 1980 to 2003, Japan's share of world industrial patents rose from 12 percent to 21 percent, and Taiwan's from 0 percent to 3 percent. By contrast, the U.S. share of patents has fallen from 60 percent to 52 percent since 1980.

Any honest analysis of this problem should note that there are some skeptics who believe that the sky is not falling and that scientists and the technology industry might be hyping some of this data, just to get more funding. A May 10, 2004, article in the *San Francisco Chronicle* quoted Daniel S. Greenberg, former news editor of the journal *Science* and author of the book *Science, Money and Politics*, who argues that "inside-the-Beltway science (lobbying) has always been insatiable. If you double the NIH (National Institutes of Health) budget in five years (as recently happened), they're (still) screaming their heads off: 'We need more money.'" Greenberg also questioned the science lobbyists' interpretation of a number of statistics.

Quoting Greenberg, the *Chronicle* said, "To put scientific publishing trends in context . . . it's important to look not only at overall percentiles but also at the actual numbers of published papers. At first, it may sound startling to hear that China quadrupled its scientific publication rate be-

izes that the actual number of Chinese papers published rose from 2,911 to 11,675. By comparison, close to a third of all the world's scientific papers were published by Americans—163,526 out of 528,643. In other words, China, a nation with almost four times the population of the United States, published (as of 1999) only one-fourteenth as many scientific papers as the United States."

While I think a dose of skepticism is always in order, I also think the skeptics would be wise to pay more heed to the flattening of the world and how quickly some of these trends could change. It is why I favor Shirley Ann Jackson's approach: The sky is not falling today, but it might be in fifteen or twenty years if we don't change our ways, and all signs are that we are not changing, especially in our public schools. Help is not on the way. The American education system from kindergarten through twelfth grade just is not stimulating enough young people to want to go into science, math, and engineering. My wife teaches first-grade reading in a local public school, so she gets *Education Week*, which is read by educators all over America. One day she pointed out an article (July 28, 2004) headlined, "Immigrants' Children Inhabit the Top Ranks of Math, Science Meets."

It went on to say, "Research conducted by the National Foundation for American Policy shows that 60 percent of the nation's top science students and 65 percent of the top mathematics students are children of recent immigrants, according to an analysis of award winners in three scholastic competitions . . . the Intel Science Talent Search, the U.S. team for the International Mathematical Olympiad, and the U.S. Physics Team." The study's author attributed the immigrant students' success "partly to their parents' insistence that they manage study time wisely," *Education Week* said. "Many immigrant parents also encouraged their children to pursue mathematics and science interests, believing those skills would lead to strong career opportunities and insulate them from bias and lack of connections in the workplace . . . A strong percentage of the students surveyed had parents who arrived in the United States on H-1B visas, reserved for professional workers. U.S. policymakers who back overly restrictive immigration policies do so at the risk of cutting off a steady infusion of technological and scientific skill," said the study's au-

thor, Stuart Anderson, the executive director of the foundation. The article quoted Andrei Munteanu, eighteen, a finalist for the 2004 Intel competition, whose parents had moved from Romania to the United States five years earlier. Munteanu started American school in the seventh grade, which he found a breeze compared to his Romanian school. "The math and science classes [covered the same subject matter] I was taking in Romania . . . when I was in fourth grade," he said.

For now, the United States still excels at teaching science and engineering at the graduate level, and also in university-based research. But as the Chinese get more feeder stock coming up through their improving high schools and universities, "they will get to the same level as us after a decade," said Intel chairman Barrett. "We are not graduating the volume, we do not have a lock on the infrastructure, we do not have a lock on the new ideas, and we are either flatlining, or in real dollars cutting back, our investments in physical science."

Every four years the United States takes part in the Trends in International Mathematics and Science Study, which assesses students after fourth grade and eighth grade. Altogether, the most recent study involved roughly a half million students from forty-one countries and the use of thirty languages, making it the largest and most comprehensive international study of education that has ever been undertaken.

The 2004 results (for tests taken in 2003) showed American students making only marginal improvements over the 2000 results, which showed the American labor force to be weaker in science than those of its peer countries. The Associated Press reported (December 4, 2004) that American eighth-graders had improved their scores in science and math since 1995, when the test first was given, but their math improvement came mainly between 1995 and 1999, and not in recent years. The rising scores of American eighth-graders in science was an improvement over 1999, and it lifted the United States to a higher ranking relative to other countries. The worrying news, though, was that the scores of American fourth-graders were stagnant, neither improving nor declining in science or math since 1995. As a result, they slipped in the international rankings as other countries made gains. "Asian countries are setting the pace in advanced science and math," Ina Mullis, codirector of the International

Study Center at Boston College, which manages the study, told the AP. "As one example, 44 percent of eighth-graders in Singapore scored at the most advanced level in math, as did 38 percent in Taiwan. Only 7 percent in the United States did." Results from another international education test also came out in December 2004, from the Program for International Student Assessment. It showed that American fifteen-year-olds are below the international average when it comes to applying math skills to real-life tasks.

No wonder Johns Hopkins University president Bill Brody remarked to me, "Over 60 percent of our graduate students in the sciences are foreign students, and mostly from Asia. At one point four years ago all of our graduate students in mathematics were from the PRC [Communist China]. I only found out about it because we use them as [teaching assistants] and some of them don't speak English all that well." A Johns Hopkins parent wrote Brody to complain that his son could not understand his calculus professor because of his heavy Chinese accent and poor English.

No wonder there is not a major company that I interviewed for this book that is not investing significantly in research and development abroad. It is not "follow the money." It is "follow the brains."

"Science and math are the universal language of technology," said Tracy Koon, Intel's director of corporate affairs, who oversees the company's efforts to improve science education. "They drive technology and our standards of living. Unless our kids grow up knowing that universal language, they will not be able to compete. We are not in the business of manufacturing somewhere else. This is a company that was founded here, but we have two raw materials—sand, which we have a ready supply of, and talent, which we don't." (Silicon comes from sand.)

"We looked at two things," she continued. "We looked at the fact that in disciplines that were relevant to our industry, the number of U.S. students graduating at the master's and Ph.D. levels was declining in absolute numbers and relative to other countries. In our K to twelve we were doing okay at the fourth-grade level, we were doing middle-of-the-road in the eighth grade, and by the twelfth grade we were hovering near the bot-

tom in international tests related to math. So the longer kids were in school, the dumber they were getting . . . You have teachers turning off kids because they were not trained. You know the old saw about the football coach teaching science—people who do not have the ability to make this accessible and gripping for kids."

One of the problems in remedying the situation, said Koon, is the fact that education in America is relatively decentralized and fragmented. If Intel goes to India or China or Jordan and introduces a teacher education program for making science more interesting, it can get into schools all over the country at once. In America, the public schools are overseen by fifty different state governments. While Intel does sponsor research at the university level that will benefit its own product development, it is growing increasingly concerned about the feeder system into those universities and the job market.

"Have we seen any change here? No, not really," said Koon. So Intel has been lobbying the INS for an increase in the number of advanced foreign engineers allowed into the United States on temporary work visas. "When we look at the kinds of people that we are trying to hire here—the master's and Ph.D. levels in photonics and optics engineering and very large-scale computer architecture—what we are finding is that as you go up the food chain from bachelor's to master's to Ph.D.'s, the number of people graduating from top-tier universities in those fields are increasingly foreign-born. So what do you do? For years [America] could count on the fact that we still have the best higher-education system in the world. And we made up for our deficiencies in K through twelve by being able to get all these good students from abroad. But now fewer are coming and fewer are staying . . . We have no God-given right to be able to hire all these people, and little by little we won't have the first-round draft choices. People who graduate in these very technical fields that are critical to our industries should get a green card stapled to their diploma."

It appears that young people wanting to be lawyers started to swamp those wanting to be engineers and scientists in the 1970s and early 1980s. Then, with the dot-com boom, those wanting to go to business school and earn MBAs swamped engineering students and lawyers in the 1990s.

One can also hope that the marketplace will address the shortage of engineers and scientists by changing the incentives.

"Intel has to go where the IQ is," said Koon. Remember, she repeated, Intel's chips are made from just two things—sand and brains, "and right now the brains are the problem . . . We will need a stronger and more supportive immigration system if we want to hire the people who want to stay here. Otherwise, we will go where they are. What are the alternatives? I am not talking about data programmers or [people with] B.S. degrees in computer science. We are talking about high-end specialized engineering. We have just started a whole engineering function in Russia, where engineers have wonderful training—and talk about underemployed! We are beefing that up. Why wouldn't you?"

Wait a minute: Didn't *we* win the Cold War? If one of America's premier technology companies feels compelled to meet its engineering needs by going to the broken-down former Soviet Union, where the only thing that seems to work is old-school math and science education, then we've got a quiet little crisis on our hands. One cannot stress enough the fact that in the flat world the frontiers of knowledge get pushed out farther and farther, faster and faster. Therefore, companies need the brainpower that can not only reach the new frontiers but push them still farther. That is where the breakthrough drugs and software and hardware products are going to be found. And America either needs to be training that brainpower itself or importing it from somewhere else—or ideally both—if it wants to dominate the twenty-first century the way it dominated the twentieth—and that simply is not happening.

"There are two things that worry me right now," said Richard A. Rashid, the director of research for Microsoft. "One is the fact that we have really dramatically shut down the pipeline of very smart people coming to the United States. If you believe that we have the greatest reseach universities and opportunities, it all has to be driven by IQ. In trying to create processes that protect the country from undesirables, [the government] has done a much better job of keeping out desirables. A really significant fraction of the top people graduated from our universities [in science and engineering] were not born here, but stayed here and created the businesses, and became the professors, that were engines for

our economic growth. We want these people. In a world where IQ is one of the most important commodities, you want to get as many smart people as you can."

Second, said Rashid, "We have done a very poor job of conveying to kids the value of science and technology as a career choice that will make the world a better place. Engineering and science is what led to so many improvements in our lives. But you talk to K through twelve kids about changing the world and they don't look at computer science as a career that is going to be a great thing. The amazing thing is that it is hard to get women into computer science now, and getting worse. Young women in junior high are told this is a really wretched lifestyle. As a result, we are not getting enough students through our systems who want to be computer scientists and engineers, and if we cut off the flow from abroad, the confluence of those two will potentially put us in a very difficult position ten or fifteen years from now. It is a pipeline process. It won't come to roost right away, but fifteen or twenty years from now, you'll find you don't have the people and the energy in these areas where you need them."

From Richard Rashid at Microsoft in the Northwest to Tracy Koon at Intel in Silicon Valley to Shirley Ann Jackson at Rensselaer on the East Coast, the people who understand these issues the best and are closest to them have the same message: Because it takes fifteen years to create a scientist or advanced engineer, starting from when that young man or woman first gets hooked on science and math in elementary school, we should be embarking on an all-hands-on-deck, no-holds-barred, no-budget-too-large crash program for science and engineering education immediately. The fact that we are not doing so is our quiet crisis. Scientists and engineers don't grow on trees. They have to be educated through a long process, because, ladies and gentlemen, this really *is* rocket science.