The Journey Inside^{SM}: Technology and Society
Student Handout: Miracle of the Microprocessor

Miracle of the Microprocessor
by Michael S. Malone, courtesy of *One Digital Day* (1998)

The microprocessor is one of the greatest accomplishments of the twentieth century. Those are bold words, and a quarter of a century ago such a claim would have seemed absurd. But each year, the microprocessor moves closer to the center of our lives, staking out its place in the heart of one machine after another. Its presence has begun to change the way we perceive the world and even ourselves. It is becoming more and more difficult to dismiss the microprocessor as just another product in a long line of technology innovations.

No invention in history has so quickly spread throughout the world or so deeply touched so many aspects of human existence. Today there are nearly 15 billion microchips of some kind in use—the equivalent of two powerful computers for every man, woman, and child on the planet. In the face of that fact, who can doubt that the microprocessor is not only changing the products we use, but also the way we live, and, ultimately, the way we perceive reality?

Yet even as we acknowledge the pervasiveness of the microprocessor in our lives, we are already growing indifferent to the presence of those thousands of tiny machines we unknowingly encounter every day. So, before it becomes too invisibly embedded into our daily existence, it is time to celebrate the microprocessor and the revolution it created, to appreciate what a miracle each one of those tiny silicon chips really is and to meditate on what it means to our lives and to those of our descendants.

First, the revolution. Were we to strip away the microchip from every application in which it now finds a home, we would be both stunned and frightened by the loss. The modern kitchen would be rendered nearly useless since the microwave, the dishwasher, and most other appliances would become unworkable. The television and VCR would fade to black, the stereo would grow mute, and most of the clocks would stop. The car wouldn't start. Airplanes would be unable to leave the ground. The phone system would go dead, as would most streetlights, thermostats, and, of course, a half-billion computers. And these are only the most obvious applications. Every factory in the industrial world would also shut down, as would the electrical grid, stock exchanges, and the global banking system. But let's go deeper: pacemakers would stop, too, as would surgical equipment and fetal monitoring systems in obstetrics wards.

All because of the loss of a tiny square of silicon the size of a fingernail, weighing less than a postage stamp, and constructed of just crystal, fire, water, and metal.

This, of course, is the miracle. Tens of thousands of microprocessors are built every day in the most sophisticated manufacturing plants ever known, where a single speck of dust can mean disaster, where processes occur in environments cleaner than any other place on earth. Even the water used to rinse the surfaces of the finished chips is purer than that used in open-heart surgery.

The modern microprocessor contains more than 42 million transistors, and each finished chip is the product of processes more complicated than those used by the Manhattan Project in building the atomic bomb. Yet despite an extraordinarily sophisticated manufacturing

process, microchips are produced en masse at the rate of more than a billion each year. To put this complexity in perspective, imagine that within each tiny microprocessor there exists a structure as complex as a mid-sized city, including all its power lines, phone lines, sewer lines, buildings, streets, and homes. Now imagine that throughout that same city, millions of people are racing around at light speed and with perfect timing in an intricately choreographed dance.

And that is just one chip. Of all the stunning statistics used to describe the world of the microprocessor, none is more extraordinary than this: the total number of transistors packed onto all the microchips produced in the world this year is equivalent to the number of raindrops that fell in California during that same period.

Faced with such stupefying numbers, it becomes even more difficult, and more vital, to ask what it all means for us and for the generations to come.

Historical precedent is a good place to start. The Industrial Revolution, which irrevocably changed the world, was brought on by a 50-times improvement in productivity—a leap so prodigious that it turned society upside down. It changed the nature of work and play; it transformed commerce, education, medicine, government, and religion. It led to new forms of art, literature, and political theory. More important, it changed forever the way we look at ourselves and our families, and at time and the universe.

But the microprocessor has already eclipsed that revolution. Evolving faster than any invention in history, the microprocessor's capability has grown ten thousand-fold over the past 25 years.

The result is not merely a world turned upside down, but one tumbling over and over down the path of history. What is remarkable, and maybe a little frightening, is that by all indications, we are only halfway through the story of the microprocessor. It is not far-fetched to suggest that it will take another century for humankind to realize all of the implications of this revolution. Thus, all the miracles we see around us today resulting from the microprocessor may be but a tiny fraction of all the wonders that we will derive from this device well into the new millennium.

The microprocessor is helping inventors propel humanity into an era of change the likes of which we have never known. It is not merely an invention, but a meta-invention which enables us to create yet other inventions. Thousands of new devices and products have been made possible by the existence of the microprocessor and by the embedded intelligence it offers despite infinitesimal demands for space or power. Millions more microprocessor-enabled inventions await their inventors.

That's only part of the story, because the microprocessor also revitalizes products and services that already exist. Look no further than your smart refrigerator or the dashboard of your car. The greatest attribute of the microprocessor is that it can embed intelligence into almost anything. It can be trained to adapt to its environment, respond to changing conditions, and become more efficient and responsive to the unique needs of its users.

Thus, the microprocessor's greatest role may be to help us design our own lives—and in doing so, to enhance that most precious of human traits, our individuality. The microprocessor is not only giving us power over our own lives, it's also the greatest instrument for achieving freedom ever invented. It's allowing us to reach out from our desks, to grasp and share knowledge that was beyond the reach of the wealthiest man in

the world just a century ago. It's tearing down the walls of the world's tyrannies. It's freeing us to work at home, wherever we choose our home to be.

By the middle of the next century, the typical microprocessor may have more computing power than today's fastest supercomputers. It will talk, and more important, it will listen. The relationship we have with it will change in almost unimaginable ways. Yesterday, the microprocessor was a tool. Today, it is a partner. And who knows what vital role it will play in our lives in the years to come?

For hundreds of years, humankind has searched for the philosophers' stone, the magical object that turns ordinary metal into gold. Who would have thought it would turn out to be a little sliver of crystal with etching on its surface? As the following pages so vividly show, the microprocessor, in the span of a single generation, has evolved from a clever technical novelty to a tireless, almost invisible partner to humanity. Today, there is no place on, above, or below the earth that it has not reached.