- Read his 1995 Turing award talk on Artificial Intelligence (AI). The Turing award is the most prestigious award given by the Association for Computing Machinery. The talk provides an excellent introduction to AI and its future. See <a href="http://www.rr.cs.cmu.edu/turing.htm">http://www.rr.cs.cmu.edu/turing.htm</a>.
- Read about Reddy's Million Book project to get a million books scanned and available free on the Web, <u>http://www.library.cmu.edu/Libraries/MBP\_FAQ.html#current.</u> <u>http://www.abc.net.au/rn/science/buzz/stories/s941429.htm</u> <u>http://www.library.cmu.edu/Libraries/LIT/Projects/1MBooks.html</u>
- Get a quick overview of the field of robotics at <u>http://en.wikipedia.org/wiki/Robot</u>.
- Get a quick overview of the field of Artificial Intelligence at <u>http://en.wikipedia.org/wiki/Artificial\_intelligence</u>.
- See Raj Reddy's vita and some of his publications at <u>http://www.rr.cs.cmu.edu/rrlong.html</u>.
- Read more about Carnegie Mellon, a world class technology university at <a href="http://www.cmu.edu/academics/schools.shtml">http://www.cmu.edu/academics/schools.shtml</a>.

Notice how this shifts the decision of what to learn and how much to learn from me (the author) to you (the reader). If you decide to explore these Web-based sources of information, you will quickly develop an *island of expertise* (a specific, small area of expertise) that likely exceeds that of most or perhaps all of your fellow students and your teachers.

Your exploration of Raj Reddy and his work might lead you to want to know more about Alan Turing—the Turing award is named after him. He was a pioneer in the early development of computers and Artificial Intelligence. There is lots of information about him available of the Web. Google the quoted expression "*Alan Turing*" and you will get more than 900,000 hits.

Why did I tell you to put the search expression in quotes? It is because a search on the unquoted expression *Alan Turing* will produce hits that contain the words Alan and Turing that are not necessarily connected together in the first name, last name order. Notice this "subtle" way that I have attempted to teach you a little about use of search engines on the Web. The Web is the world's largest library, and it is a virtual library. The knowledge and skills that you gain in learning to make effective use of virtual (not hard copy) libraries will be of value to you throughout your lifetime.

Notice that a couple of the references are to materials from the Wikipedia—an online, multiauthor, unrefereed, free encyclopedia. There has been considerable brouhaha—especially among teachers—concerning students making use of this unrefereed material. Personally, I find the Wikipedia quite useful and I use it frequently. In addition, it provides an excellent example of cooperative, collaborative writing. Volunteers write it, and the volunteers often rewrite each other's writings.

## Helping Yourself to get a Better Education

The goal of this book is to help you get a good education. This is a "self-help" book, in that it is designed to you learn to help yourself get a better Information Age education.

The Raj Reddy example illustrates self-help. As you read that section, you made a decision —based on intrinsic motivation, time pressures, and so on—as to whether you would make use of the Web links that I provided.

Let me give a different, concrete example of self-help. The beginning of this Preface contains the quote from Louis Pasteur: "Fortune favors the prepared mind."

When you read this quote from Louis Pasteur, did your mind "blip" over it, or did you pause to reflect on what this statement might mean, and why this book about computer technology quoted a person who died long before the first electronic computers were built? Did you reflect on your knowledge about Louis Pasteur and how his work has affected your life? Did you consider using a search engine to look up some information about Louis Pasteur? If you looked up some information on the Web, you might have come across:

If one were to choose among the greatest benefactors of humanity, Louis Pasteur would certainly rank at the top. He solved the mysteries of rabies, anthrax, chicken cholera, and silkworm diseases, and contributed to the development of the first vaccines. He debunked the widely accepted myth of spontaneous generation, thereby setting the stage for modern biology and biochemistry. He described the scientific basis for fermentation, wine-making, and the brewing of beer. Pasteur's work gave birth to many branches of science, and he was single handedly responsible for some of the most important theoretical concepts and practical applications of modern science. (Rhee, 1999)

One of the differences between a storybook and an academic book is the density of ideas. In a storybook, you can skip over quite a bit of the content and still get the gist of the story. It is not expected that you will reflect on the meaning of each paragraph.

In contrast, an academic book is written with the expectation that you will read and reflect. You will actively engage your mind in thinking about how the content of the textbook fits in with what you already know. You will take responsibility for reconciling differences between your current knowledge and skills, and those being discussed in the book. A decision to "blip" even one short sentence is a decision to get less from the book than might otherwise be possible. The main learning that comes from a book such as this occurs though the reader pausing to reflect, do a mental exploration, and perhaps doing additional exploration of an idea.

#### **Assessing Your Current Education**

How good has your previous informal and formal education been? Can you self-assess—that is, tell all by yourself how good you education has been?

You can think about the processes of your education, such as the time spent playing sandlot sports, board games, and computer games. You can think about your years in school, the books you have read, the music you have listened to, the video you have watched, and the conversations you have had. You can think about music lessons, sports camps, boy scouts or girl scouts, and so on. All of these are aspects of the process of your informal and formal education.

However, I want you to dig deeper. **How good have the results been** from your point of view and from the point of view of others? How does the quality of your education match up to expectations of your parents, your spouse or a potential spouse, your employer of a potential employer, and so on? How does you education compare with that of your peers? Does your education appropriately prepare you for the overall future that you envision for yourself? Have you learned to take responsibility for your future education and for the challenges of a responsible adult life in a rapidly changing world?

The previous paragraph provides a good example of the challenge of reading an academic book. It is written at about a 10<sup>th</sup> grade reading level. You can probably read this much text in 20 seconds or so. However, it can take a great deal of time to think about the questions and to explore answers. The paragraph is only useful to you if you spend time in reflecting about your answers.

This reflection process is key to your future informal and formal education. You have reached a level of maturity where you should be taking considerable responsibility for your own education. You have the experience, knowledge, and skills to gain an education that fits your personal needs. Only you can tell if you are achieving these types of informal and formal educational goals.

## Your Personal Goals in Education

Before proceeding to the next chapter, stop for a minute and think about your goals in higher education. Here are three areas that might come to your mind:

- 1. I want to increase my level of expertise in various areas that are in the college or university curriculum. I expect to receive written documentation (transcripts, certificates of accomplishment, diplomas, and so on) that helps provide evidence of my increasing expertise.
- 2. I want to increase my level of expertise in a number of extracurricular areas (such as social skills, relationships with others, sports, and recreation). In cases where one can accumulate evidence of increased expertise (such as golf handicap or other spots performance), I want to have evidence of my increasing level of expertise.
- 3. I want my higher education time, expense, and effort to help me increase various areas of expertise more efficiently and effectively than I could in other settings.

Note that your goals in (1) and (2) can strongly overlap. There is no find dividing line between curricular and extracurricular goals and activities. In thinking about (3), be aware that learning goes on all of the time, whether you are in school, holding down a job, raising a family, or vacationing.

As you think about your personal goals in education, think about how you can tell if you are achieving your goals. Robert Sternberg is a world-class expert in human intelligence. He defines intelligence "your skill in achieving whatever it is you want to attain in your life within your sociocultural context by capitalizing on your strengths and compensating for, or correcting, your weaknesses." The reference (Sternberg, 2007) provides access to video (and a transcript of the video) in which Sternberg presents and discusses some of his insights into intelligence.

Whatever goals you have set for yourself, read this book with these goals in mind. This book will prove useful in moving you along the pathway of understanding and achieving your goals,

#### Summary and Self-Assessment

Each chapter of this book ends with a brief section that mentions a few of the important ideas in the chapter and suggests some ways you can self-assess your understanding of these ideas. Right now, without looking back at the material in the Preface and in this chapter, try to name several ideas from the material that seem important to you.

- If none of the ideas seem important to you, then name an idea that I thought was important enough to emphasize, and do a mental rehearsal of why this idea does not seem important to you.
- If you cannot recall any major ideas from the material, then reflect on how you have spent your time "reading" the material without having any of the ideas actually ending up in your retrievable memory.

Now, go back and quickly browse the headings for the various sections. Select one topic that seems particularly important to you, and select one that seems relatively unimportant to you. Do a mental compare and contrast between these two topics. Do a mental rehearsal of what you would say to me (the author) about ways to improve these two sections, or why one of the sections should be deleted.

From my point of view, the single most important idea in the material is learning to take increased responsibility for one's own education. The message to you is to set some learning goals for yourself, work to achieve these goals, and learn to self-assess your progress in achieving these goals. Of course, I hope that your personal goals will include learning various aspects of ICT!

# Chapter 2

## **Inventing Your Future**

"The best way to predict the future is to invent it." (Alan Kay)

"Would you tell me please, which way I ought to go from here?" asked Alice. "That depends a good deal on where you want to get to, said the Cat." (Louis Carroll, Alice's Adventure in Wonderland.)

Please read the "pithy" quotes at the beginning of the chapter and reflect on their possible meaning. Alan Kay has made many very significant contributions to the computer field. His name is closely associated with the development of laptop computers and with the graphic user interface (clicking on icons to make things happen) that is now standard on microcomputers. In 2003, he received the Association for Computing Machinery's Turing Award for his lifetime of contributions to the computer field. His lifetime has, indeed, been one in which he helped to invent the future.

Throughout each day, you make decisions that will impact on your future. From time to time, you make large decisions that you know will have a significant impact on your future. Your decision to pursue higher education is a good example of inventing your future.

Predictions about the future are usually based on having good knowledge about the past and present. Thus, this chapter is based on:

1. Information about the past and present.

2. Some forecasts for the future.

#### A Little Bit of Computer History

About the time of World War II, the electronic digital computer was developed independently in England, Germany, and the United States. Alan Turing's computer development work in England played an important role in decoding secret German messages, thus contributing substantial to England's war efforts.

More than 50 years ago, in the late 1940s, it was not too clear that computers were here to stay. They were expensive, bulky, unreliable, and difficult to use.

The United States was the third country (after Great Britain and Germany) to begin the commercial production of electronic digital computers. The first commercially produced computer in the United States was the UNIVAC I, delivered in March 1951. Priced in the range of \$1.25 million to \$1.5 million, the UNIVAC I machine had about 5,200 vacuum tubes, weighed 29,000 pounds, and could perform 1,905 operations per second. Only 46 of these machines were built over a period of about seven years.

The early computers were cost effective on some jobs. For example, in certain types of repetitious calculations—such as payroll— one computer could do the work of many hundreds of people who were using electric calculators. Such massive amounts of computation were also useful in a variety of science and technology situations, such as designing nuclear weapons.

Computer technology has changed a lot since 1951. Much of this change has been made possible by the invention of the transistor. At the time the UNIVAC I was being produced, a vacuum tube cost about a dollar. The transistor had been invented only a few years earlier and initially cost many times as much as a vacuum tube. However, in many electronic circuits, a transistor could replace a vacuum tube, be much more reliable, and use much less power. Moreover, progress in transistor technology soon decreased their price (PBS, 1999).

Adjusting for inflation, in today's dollars the cost of a UNIVAC I was in the range of \$8 million to \$10 million. Contrast this with today's \$1,000 laptop or desktop microcomputer that can do two billion operations per second. A rough calculation indicates that the cost per calculation has gone down by a factor of 10 billion since the early 1950s.

Ten billion! Think about that factor of change. Try to develop a useful level of understanding about this huge number and huge factor of change.

Today's thousand-dollar microcomputer rivals the multimillion-dollar supercomputers of 20 years ago. The torrid pace of improvement in computer price to performance ratio seems likely to continue for a number of years into the future. Thus, it might well be that 20 years from now students will be buying microcomputers that rival today's multimillion-dollar supercomputers.

Along with substantial improvements in computer speed, the past 50 years have seen substantial improvements in computer memory, secondary storage devices, and in telecommunication systems. Price to performance ratios have improved by factors of more than a million.

Here is a specific example. Microcomputers came into widespread use in the late 1970s and early 1980s. In those days, a 5-megabyte hard disk drive for a microcomputer cost about \$5,000. This is \$1,000 per megabyte, or \$1,000,000 per gigabyte. Now, the cost of a hard drive is less than 50-cents per gigabyte.

Here are two more specific examples. The Russian satellite Sputnik was launched into orbit in 1957. Now, dish TV and satellite-based Global Positioning Systems (GPS) are routine consumer products. The first commercial installation of fiber-optic cables for telecommunication was in 1977. Now, one fiber-optic cable can carry hundreds of thousands of phone conversations, and cables are typically installed in bundles of many cables.

Many areas of research and development depend upon ICT. In some sense, the greater the ICT dependence, the greater the rate of progress. The human genome project provides a good example of a speed up in technological progress. The project that began in 1990 and ended in 2003 cost about \$300 million. Initial progress on the project was very slow. Progress speeded up considerably as the project proceeded, and most of the sequencing was complete in the last couple of years.

In 2005, the cost of sequencing a person's genome was estimated to be about \$2.2 million, and various organizations and people believe that the cost may eventually be as low as \$1,000 (Wade, 2006).

These massive changes in ICT-related capabilities and price to performance ratios are major change agents. From your personal point of view, perhaps the major challenges are accommodating appropriate aspects of these changes into your everyday live, and getting an education that helps prepare you for the continuing high rate of change in ICT.

#### **Forecasting the Future**

A very short description of science is, "Science is description and prediction." Scientists have made good progress in describing our solar system and predicting where the moons, planets, and various comets will be many years in the future. Scientists have an increasingly good understanding of astronomy, biology, chemistry, geology, physics, and many other areas of science.

However, there are many areas of scientific research where it is difficult—if not downright impossible—to make accurate long range forecasts. For example, weather forecasters regularly provide weather forecasts for the next day, week, or month. The longer into the future these forecasts go, the less accurate they become. Forecasts of earthquakes and volcanic eruptions are not very accurate.

Now, consider forecasting in areas such as the stock market, consumer purchases, and other human activity areas. While forecasters in these areas often make use of scientific methods and computers, they lack the underlying theories that make possible the accurate predictions of the sciences. Will consumers like and buy a proposed new product or service? Will a movie or TV series that is being planned attract a large audience? Will a racehorse stumble and break a leg?

Where does this leave you, as you plan for and work to achieve your higher education aspirations? What might the future look like? How can you plan for a future world that might be a lot different than our current world?

Well... I can give some advice, but I cannot guarantee it will work for you. Here is the way I see it:

- 1. Plan for a future world in which there will be an increasing number of people. Work to improve your people skills and to improve your ability to function in a world being made "smaller" by steady improvements in transportation, communication, and worldwide competition for jobs.
- 2. Plan for a world that faces a steadily increasing pressure on the world's resources, worldwide competition for these resources, and a steadily increasing challenge of sustainability. Global warming is a massive challenge.
- 3. Plan for a world in which there will be a still faster pace of change in science and technology. How will you deal with progress in genetics (gene therapy, cloning, designer babies), drugs to enhance mind and body, and entertainment that is steadily growing in its attention grabbing and attention holding capabilities?
- 4. Plan for a world in which you will need to be a lifelong learner and will need to make many changes to accommodate large changes going on in the world. Assume that computers will get steadily "smarter" and that computerized equipment will get steadily more capable. You will need

to deal with these types of changes in your work, family and personal life, and leisure.

A good starting point is to increase your understanding of the current situation and near term future situation in various rapidly changing areas of science and technology. An easy way to do this is to spend some time viewing some of the free videos that are available on the Web. Examples are given in the next section.

#### **Some Visionaries**

ICT and the underlying discipline of computer and information are large and steadily growing. One way to gain some insight into the future of these areas is to study some of the work of leading researchers and practitioners. Learn about a few of the movers and shakers. Pay attention when you hear there names in the news or see articles written about them. I find it particularly interesting and useful to read some of the talks and view some of the videos of these leaders.

This section provides brief introductions to a few of the people who are creating the future of ICT. These people are sufficiently visionary that one doesn't need to study their most recent publications to gain useful insight into where they think the world is heading. Indeed, I find it is fun to read some of their older work and see how well they have predicted the future.

You are undoubtedly familiar with Bill Gates (Microsoft) and Steve Jobs (Apple) and the ongoing contributions they and their companies are making to the ICT world. There are many other entrepreneurs and visionaries who are changing our world. *The 50 Most Important People on the Web* (Null, 2007) contains brief discussions about many of these people. You might want to build an island of expertise based upon knowing about some of these people. The following sections focus on people that I consider especially noteworthy.

#### Ray Kurzweil: The Singularity is Near

Ray Kurzweil is a prominent computer-oriented futurist. He did his doctoral work in Artificial Intelligence under the supervision of Marvin Minsky, who is one of the pioneers of this field. He was awarded the National Medal of Technology by President Clinton and has received a number of other high level awards. He is an entrepreneur who has started a number of high tech companies (Kurzweil Technologies, n.d.).

Kurzweil's book: *The Singularity is Near: When Humans Transcend Biology* contains a number of forecasts, with a special emphasis on genetics, nanotechnology, and robotics. The *singularity* referred to in the title of his book is a time when computer intelligence exceeds human intelligence.

Quoting from his book (Kurzweil, 2005, page 136):

I set the date for the Singularity—representing a profound and disruptive transformation is human capability—as 2045. *The nonbiological intelligence created in that year will be one billion times more powerful than all human intelligence today*. [Italics added for emphasis]

Before you dismiss such a wild-eyed forecast out of hand, examine Kurzweil's credentials and his record of success as a far out thinker and forecaster. Quoting from (Kurzweil Technologies, n.d.):

Ray Kurzweil was inducted in 2002 into the National Inventors Hall of Fame, established by the U.S. Patent Office. He received the \$500,000 Lemelson-MIT Prize, the nation's largest award in

invention and innovation. He also received the 1999 National Medal of Technology, the nation's highest honor in technology, from President Clinton in a White House ceremony. He has also received scores of other national and international awards, including the 1994 Dickson Prize (Carnegie Mellon University's top science prize), Engineer of the Year from Design News, Inventor of the Year from MIT, and the Grace Murray Hopper Award from the Association for Computing Machinery. He has received twelve honorary Doctorates and honors from three U.S. presidents.

Now that you are suitably impressed by some of his credentials, you might want to:

- Learn more about Kurzweil and his work by viewing the 25-minute video of when he was awarded the year 2001 seventh annual \$500,000 Lemelson prize. See: <a href="http://www.lemelson.org/innovation/3ivision.php">http://www.lemelson.org/innovation/3ivision.php</a>.
- See Kurzweil's optimistic views of our future. For a 24 minute video of a talk given in 2005, see <a href="http://ted.com/tedtalks/tedtalksplayer.cfm?key=r\_kurzweil">http://ted.com/tedtalks/tedtalksplayer.cfm?key=r\_kurzweil</a>.
- Learn more information about Kurzweil and artificial intelligence, see KurzweilAI.net at <u>http://www.kurzweilai.net/</u>. If "far out" thinking about the future interests you, this is a great site to explore. For example, at <u>http://www.kurzweilai.net/meme/frame.html?main=memelist.html?m=4%23688</u> you can read a transcript of a November 30, 2006 debate on machine consciousness.

After you have viewed one of more of the videos listed above, spend some time thinking about how Kurzweil's vision of the future of technology fits in with your forecasts of the future you are preparing for through your higher education. There is no guarantee that Kurzweil's forecasts will prove to be accurate. While many people agree with his thinking, many others strongly disagree. My personal opinion is that you and other students should be preparing yourself for life in a world where many of Kurzweil's forecasts have proven to be relatively accurate.

#### Thomas Friedman: The World is Flat

Thomas Friedman is a three-time winner of the Pulitzer Prize. His 2005 book, *The World is Flat: A Brief History of the Twenty-First Century*, captures many of the key ideas of change going on throughout the world due to ICT, improvements in transportation, and improvements in education. Friedman's use of the term *flat* is intended to convey the idea of a level playing field in the worldwide production and sale of goods and services (Friedman, 2005).

One example of this flatness is the cost of long distance phone calls. If you and the person you want to talk to can connect on the Internet, you can carry on a "free" phone conversation via the Internet. That is, the only cost is whatever you are paying already to have the Internet connectivity. Indeed, if you both have appropriate video cameras such as those now often build into computers or that can be purchased at a modest cost, you can carry on videophone conversations.

A Google search of *Thomas Friedman video* will provide you with access to a number of his talks and interviews. Many of these are more than an hour in length—he has a lot to say! Here are two recommendations:

• Doing Business in a Flat World: Globalization, Entrepreneurship, Micro-Economic *Reform*, a presentation on the factors that have contributed to the increasing

connectedness—or "flattening"—of the world. A 1.5 hour presentation is available at <u>http://info.worldbank.org/etools/Bspan/PresentationView.asp?PID=1507&EID=732</u>.

• Learn more about Friedman and access some of his writings at <a href="http://www.thomaslfriedman.com/">http://www.thomaslfriedman.com/</a>.

As you think about and plan for your future, remember the tune "It's a small world" and pay attention to Friedman's insights that the world is getting smaller. Work to become a citizen of the world who functions well in a rapidly changing world that is growing smaller and flatter.

#### Nicholas Negroponte: The One Laptop Per Child Project

ICT is a worldwide reality. However, it is more of a reality in some parts of the world than in others. Nicholas Negroponte is former Director of the MIT Media Lab, one of the world's leading ICT-based, education-oriented, research and development centers. Quoting from the Wikipedia:

The MIT Media Lab in the School of Architecture and Planning at the Massachusetts Institute of Technology engages in education and research in the digital technology used for expression and communication. It was founded in 1985 by MIT Professor Nicholas Negroponte and former MIT President Jerome Wiesner (now deceased).

Negroponte is dyslexic, which makes reading and writing more of a challenge than it is for non-dyslexic people. His 1995 book *Being Digital* presents a clear picture of similarities and differences of being in the business of moving bits (of information) versus moving physical (solid objects) made up of atoms (Negroponte, 1995). Quoting from this book:

The best way to appreciate the merits and consequences of being digital is to reflect on the difference between bits and atoms. While we are undoubtedly in an information age, most information is delivered to us in the form of atoms: newspapers, magazines, and books (like this one). Our economy may be moving toward an information economy, but we measure trade and we write our balance sheets with atoms in mind.

•••

The information superhighway is about the global movement of weightless bits at the speed of light. As one industry after another looks at itself in the mirror and asks about its future in a digital world, that future is driven almost 100 percent by the ability of that company's product or services to be rendered in digital form.

Thus, for example, an electronic copy of a book can be in a repository, and electronic copies can be quickly distributed around that world at a very low cost. The same situation holds for distributing music.

Negroponte is playing the lead role in an effort to bring inexpensive networked computers to the world. The *One Laptop Per Child* project is dedicated to making a networked \$100 laptop a reality. The designers of the machine realize that many of the people they want to reach do not have electrical power. The machines consume so little power that they can be human powered (think in terms of a wind up flashlight).

Mass production of these computers began in the first quarter of 2007, with the expectation of first deliveries to begin in the summer of 2007. The first machines are being sold in large lots (think of selling a million computers at a time to a government) with about seven different countries interested in making the initial purchases. Initially, the machines will cost in the range of about \$160 to \$175, but the expectation is that eventually they will cost under \$100.