Living on the Future Edge
(Off We Go Into the Wired & Unwired Blue Yonder!)

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Synopsis
Today, in a world where change is the constant, you just can't trust your eyes. As a result, the true power & potential of existing trends can only be understood as part of the remarkable growth in speed and power of computational technologies that has occurred over the course of the past 50 years. This presentation traces the amazing continuum of development from the building based computers of yesterday to the digital wonders of today and the astonishing implications they hold for tomorrow. By carefully explaining the significance of six exponential trends (Moore’s Law, the Law of the Photon, the emergence of the Internet, the Age of InfoWhelm, The Age of Biotechnology, and Nanotechnology) this presentation profoundly challenges your fundamental assumptions about new technologies and the impact they will have on our lives, our organizations and personal beliefs. The presentation then asks you to stand back from these trends and consider how these developments will change our learning institutions, the classroom, the curriculum, learning, instruction and even our fundamental definition of intelligence.
These are difficult times
Today in our crazy world, we all have to deal with what we like to call “the tyranny of the urgent” and the “tyranny of everyday life” – we live in a world that seems to be changing so quickly that long range planning is reduced to what we’re going to have for dinner tonight. When we’re in a chronically reactive mode, it’s very difficult to step back and detach ourselves from the hear and now so that we can really carefully examine the issues of change.

Let’s talk about change
These are tough times, particularly for education and particularly since 9/11. Today in our business, we’re just not dealing with change; we’re dealing with an increasing rate of change that all but overwhelms us. I call this the tyranny of the urgent and everyday life. For some, the change is so overwhelming that it’s sometimes difficult to grasp the significance of what’s happening. Yet despite the dramatic events of the past 6 months, much of the change process is both subtle and sneaky. We all know that something is going on, but it’s often difficult to put your finger on exactly what’s happening.

I think what puts this into perspective for me is my son Kyler. This is a picture of Kyler taken when he was 6 months old and weighed 18 pounds:

And this is a picture of Kyler taken recently:
Can you believe it? 6' 5", 290 pounds and size 18 EEEEE running shoes!!!! When did this happen??!! And why didn't I see it coming. I mean, it's hard for me to believe that this is the same little guy who used to fall asleep on my chest at night. If he did that now, he'd kill me.

And you see, whether we're talking about change in our children, change in our lives, change in our institutions, because of this thing called the tyranny of the urgent - the tyranny of everyday life - terminal overwhelm, it's hard for us to understand. In fact, it's the scale and the scope of the changes that are difficult to comprehend. Why? Because we're not just talking about change today and let's go back to being "normal" tomorrow. No - we're talking about change today, change tomorrow, change forever. We're talking about constant and never-ending change.

**Let's use that to talk about technology**

Have you noticed the absolutely amazing array of new devices and gadgets that seem to have suddenly appeared on the scene? It brings a whole new meaning to the notion of "disposable income." The future, literally, is in the palms of our hands.

Think about it. If in 1960 all the computers in the world had stopped functioning, few people would have noticed. A few 1000 scientists would have seen a delay in getting printouts from their last submission of data on punch cards. Some business reports would have been held up. Nothing to worry about.

Today is another matter. If all computers in the world stopped functioning, society would grind to a halt. First of all, electric power distribution would fail. Even if electric power continued, virtually everything would still break down. Most motorized vehicles have embedded microprocessors, so the only cars that would run would be quite old. There would be almost no functioning trucks, buses, railroads, subways, or airplanes. There would be no electronic communications: telephone, radio, TV, fax machines, pagers, email and the Web would all cease functioning. You wouldn't be able to your paycheck. You couldn't cash it if you did. You wouldn't be able to get your money out of your bank. Business and government would operate only at the most primitive level.

In less that 40 years we have gone from manual methods of controlling our lives and civilization to becoming totally dependent on the continued operation of our computers.

The remarkable aspect of this development is that technology isn't just changing, there seems to be an ever-accelerating rate of change. Things are happening so
quickly that it’s almost impossible to keep up with all of the developments. That’s because we are dealing with exponential growth in the speed and power of electronic devices. What is exponential growth? It’s change that is happening so quickly that our minds quite simply can’t keep up.

There’s a critical point embedded in these observations. Despite the continued proliferation of new gadgets, the issues we face today are less to do with hardware than they are to do with headware. When push comes to shove, dealing with all these changes has far less to do with the gadgets than it does with people and their mindsets or paradigms. The problem is that historically, changes in mindset have always tended to lag behind changes in technology. There are many visionary examples of this from the annals of history:

"What can be more palpably absurd than the prospect held out of locomotives traveling twice as fast as stagecoaches?" – The Quarterly Review, England, 1825

“This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value.” – Western Union internal memo, 1876

“The horse is here to stay but the automobile is only a novelty, a fad, a passing fancy.” – President of the Michigan Savings Bank advising Horace Racham (Henry Ford’s lawyer) not to invest in the Ford Motor Co., 1903

“While television may be theoretically feasible, commercially & financially I consider it an impossibility, a development of which we need waste little time dreaming.” – Lee DeForest, (American radio pioneer), 1926

“There is not the slightest indication that nuclear energy will ever be obtainable. It would mean that the atom would have to be shattered at will.” – Albert Einstein, 1932

Now while we may laugh at the lack of vision in these statements, it must be made clear that these folks weren’t stupid, it’s just that at every stage in our history, new technologies have been a challenge to the existing mindset.

This is because some of these new technologies have fundamentally changed the way things have been done – in many cases, the way things have been done for years even decades or centuries. And as this happens, these changes tend to challenge our
existing mindsets as they push us out of our comfort zones. As a result, it’s often difficult (at least at first) to grasp the significance of any one development in isolation. This is because many of the changes force us at a fundamental level to confront the very essence of our human nature. At what point in viewing some of these new developments do we say ‘Never?’ “This will never happen in my life.” Because never seems to happen a lot sooner than ever before. What sounds weird today will frequently become common tomorrow. Often this is not you, but your paradigm speaking.

Why are the changes happening so quickly?
The upheaval in our lives is due in large part to the Exponential Revolution in our world. To appreciate the Exponential Revolution, you must first understand the power of doubling. To illustrate what doubling technological power will look like, let’s use an analogy. Imagine you were going to build an addition onto a school. You have responsibility for the project, and have just received the bids for the work to be done. Predictably, they are all fairly close to the projected cost of $3 million.

However, the last bid has a remarkable proposal. It comes from a well-respected contractor and it goes like this: the contractor will only charge one cent for the first day of work including all materials, equipment, and labor. The only thing he asks is that you double the amount he is paid each day for a month —let’s say August. That’s it. After a month, he will not charge you another penny, no matter how long it takes to complete the work. Right off the top, this sounds like a great deal, right? Since this proposal comes from a good contractor, you decide to take him up on it. Now let’s see how it works out. Your payments start off like this:

<table>
<thead>
<tr>
<th>Day</th>
<th>Amount</th>
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<tr>
<td>1</td>
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After 10 days your total output has been $10.23. No problem. In fact, this is better than our wildest money saving dreams! Let’s continue...

Day 12 $20.48
Day 13 $40.96
Day 14 $81.92
Day 15 $163.84

Half the month is over and you are laughing all the way to the bank. Your total expenditure is now just $327.67.

Day 16 $327.68
Day 17 $655.36
Day 18 $1,310.72
Day 19 $2,621.44
Day 20 $5,242.88
Day 21 $10,485.76
Day 22 $20,971.52

Day 22 is an important one to ponder. You can see that the contractor is now starting to get a reasonable amount of money for each day, but you have still only paid out a total of $41,943.03. This is still far below the other bids of $3 million. This seems too good to be true – and it is. Watch what happens as the doubling effect really begins to kick in.

Day 23 $41,943.04
Day 24 $83,886.08
Day 25 $167,772.16
Day 26 $335,544.32
Day 27 $671,088.64
Day 28 $1,342,177.28
Day 29 $2,684,354.56
Day 30 $5,368,709.12
Day 31 $10,737,418.24

It’s time to call 9-1-1

The total you would end up paying is more than $21 million! Wow! It’s important to note that the doubling has the greatest impact in the last few days (why didn’t you build it in February?). In the beginning, did you really have any idea that starting at one cent would lead to such an astonishing amount? The answer for most of us would
certainly be no. This is the power of exponential growth - what Gladwell in this book calls the Tipping Point calls the exponential tipping point where change goes from being lineal & relatively predictable to being massive & sudden. This is the power of exponentialism.

What are the exponential trends?
There are six exponential trends that no one can ignore, no matter how close they are to retirement. Trend number 1 is:

Trend #1: Moore's Law
Gordon Moore was the co-founder and chief research scientist of Intel Corporation, the leading manufacturer of microchips for computers in the world today. In 1965, in Electronics magazine, he proposed Moore's Law. The law predicted that the processing power and speed of any electronic calculating device would double every 18 months, while at the same time that the price for that technology would decline by about 50% in value relative to the power. This is exponential (as opposed to linear) growth. So far, Moore's prediction has been uncannily accurate, but it's very hard to grasp the significance of Moore's Law because the mind simply can't keep up.

To provide a context to exponential growth, let's consider the development in the power of computational devices from the beginning of time. Truly, necessity is the mother of invention. Computers grew out of a human need to quantify things. Early humans were content to count with fingers or rocks. As cultures became more complex, so did their counting tools. The abacus, the Arabic number system, and the concept of zero are only three examples of early calculating tools. Each of these ideas spread rapidly and had an immediate and profound effect on society.

Many factors have contributed to the growth in technological power. The growth in population; the increased complexity of the economy; a need for the more powerful computational power required to monitor and manage an increasingly complicated world; and, of course, war technology. All have lead to an increasing demand for more and more sophisticated calculating devices. But there was very little increase in power for most of the 10,000 years of recorded human history. The real growth began with the emergence of electronic calculating devices into our lives. It's growth that has been compressed into little more than the last 50 years. However, at every step of the way, our understanding and application of the technology has lagged behind the development of new technologies.

"I think there is a world market for maybe five computers." - Thomas Watson, chairman of IBM, 1943
Let’s consider the Eniac computer that first came on-line in February 1946. The Eniac, which cost $750,000 in 1946 dollars (about 10 kabillion dollars today) was a 30 ton building-based computer designed to calculate trajectory tables for new guns. It covered two floors - one for the computer and one for the cooling system. The Eniac had 6,000 switches, 70,000 resistors, 500,000 hand-soldered capacitors and more than 19,000 vacuum tubes that inevitably attracted moths (that’s where the term “bug report” came from). One of these tubes failed on average every 7 minutes. It wasn’t what we’d call user friendly. But when it was running, it could complete a 10-digit multiplication in 3/1000ths of second. Relative to what had come before, this was a huge jump forward in processing power and its development held huge implications for the people of the time. Yet still the mindset lagged behind the technology.

“Computers in the future may have only 1,000 vacuum tubes and weigh perhaps 1.5 tons.” – Popular Mechanics, 1949

Over the course of the next several decades, countless advances in technological power occurred. In the early 60s the introduction of the IBM 360/370 lead to a remarkable acceleration in power and performance. This maturation of the mainframe and a new generation of room-based computers turned IBM into a computer giant. Then in the mid-60s, DEC introduced the powerful new PDP computers, which were made possible by large-scale integration through the photographic reduction of circuits onto silicon chips.

And in 1969, Intel Corporation introduced the first microprocessor - a CPU on chip. This was absolute conceptual dynamite! What had been the size and cost of a mansion little more than 20 years previous was now the size of a stamp and the cost of a dinner. This was the beginning of a wave that would engulf us all. But still mindset lagged behind the emerging technology. When shown the microchip in 1969, an engineer from IBM’s Advanced Computing System Division commented:

“But what is it good for?”

For most of us, calculators were the first manifestation of the technological revolution. Big, ungainly and relatively limited in their capabilities, their design nonetheless clearly demonstrated that electronics manufacturers were technically able to make microcomputers. However, there was still very little understanding of, or demand for microcomputers, so initially, they could only be acquired as kits, which required hundreds of hours of painstaking assembly. In 1974, the Altair appeared -
it had neither a keyboard nor a monitor and was programmed by methodically flipping hundreds of switches. It featured an awesome 1/4 K (256 bytes) of memory, which meant you could fit in your first name or your last, but not both at the same time.

In 1976, the Radio Shack's TRS 80 became the first commercially available first pre-assembled microprocessor. The entire CPU was contained in the keyboard, data storage was made through a tape recorder, and it had a remarkable tendency to lose all data when the keyboard was placed too close to the monitor. Just about the only decision to be made was whether you were going to have 4K on board or go all the way to 8K. Nevertheless, relative to the cost and size of previous computers, the capabilities of the TRS 80 were absolutely amazing! Still many people just didn’t get it.

“There is no reason for any individual to have a computer in their home.” – Ken Olsen, president and founder of Digital Equipment Corporation, 1977

Shortly thereafter, along came the Apple I. Most of us have heard the remarkable story about two young entrepreneurs, Steve Wozniak and Steve Jobs, who started working in a garage. Atari rebuffed them when they offered to give them their invention. And what an amazing device it became - standard 16K of memory, with the ability to expand all the way up to 64K. Disk drives replaced tape recorders as storage devices. Desktop printers replaced floor printers. For those who had followed the development of computers since the early days, this was a remarkable event. A complete computer system on the desktop could be had for under $5,000.

As a result of their work, in the summer of 1979 the revolution really began when business discovered microcomputers. An absolute sales explosion ensued as Apple, Commodore, Radio Shack, Sperry and Osborne products brought what had previously been the mainframe to desktop. This heralded a new age of personal productivity. But once again, we saw that with the new technology came an old perspective. As a result, these desktop computers were initially viewed as little more than electronic typewriters in much the same manner that the first automobiles were initially seen as horseless carriages. In both cases, it took people many years to get beyond this thinking.

This is what paradigm paralysis is all about. Perspectives are often held back by previous experiences that delay or limit our ability to understand and use new technology. As a result, when they initially appeared, there was a great deal of misunderstanding about the devices; and consequently, an enormous amount of unused
potential. This particularly applied to education, where English teachers struggled (and some continue to struggle) trying to understand how to use computers to enhance the writing process; and in Business Education, where teachers were unable to comprehend the potential of spreadsheets and data processing in reinventing business practices.

"I have traveled the length and breadth of this country and talked with the best people, and I can assure you that data processing is a fad that won’t last out the year." – the editor in charge of business books for Prentice Hall

Let’s use a table initially developed some years ago by David Thornburg to put Moore’s Law into perspective - in 1979 computers typically had 16K of RAM, 5 1/4" floppy disk that held 128K of files, a blazing 2mHz processor (translated into non-technical terms... SLOW!!!) and at a cost of $5,000.

![Moore's Law Table](image)

From this point forward, things began to move rapidly. One important benchmark was IBM’s role. IBM helped set the standard for the new PC industry because of their pivotal role in the development of mainframes and minicomputers. But because they came from a mainframe mindset, they initially showed contempt and disdain for the microcomputer market. Their developers wondered out loud why anyone would need a PC - and this clearly showed in their system design strategies.

For the sake of speed, simplicity and cost, IBM did not build a proprietary system - instead of using its own in-house technology, as was usually the case, it used industry-standard components available to anyone bent on entering the market. A little known aspect of this story is that in large part due to this, they decided to
contract a small entrepreneur from Bellevue, Washington to develop an operating system for the IBM PCs – this was known as PC DOS. But because of the less than careful manner in which the contract was written, three months later Bill Gates released Microsoft DOS and the die was cast.

Naturally the first iterations of the operating system were clunky. It became accepted as simple fact that using technology was painful – and that in order to properly use the machines, you had to spend long hours hunched over a keyboard learning to speak in technological tongues in order to become part of a specialized priesthood.

Meanwhile, over at Xerox's Palo Alto Research Center (PARC), a small group was working on a fundamentally new concept. The Alto was a windows-based computer that used a graphical user (point and click) interface. With this concept, Xerox could have cornered the market on PCs, but they just couldn't see the potential. They did very little with the concept. Enter Steve Jobs from Apple, who had a semi-religious experience when he saw the Alto for the first time. In short order, he bought it and renamed it first as the Lisa and then the Macintosh. For many, this event has been heralded as the most significant conceptual breakthrough in the history of PCs, as in 1998, Microsoft held its cutting edge product Windows '98 up to a standard that was set back in the 70s at PARC.

"I see no advantage to the graphical user interface." - Bill Gates, Chairman of Microsoft, 1984

Meanwhile, the relentless power of the doubling of Moore's Law was really starting to impact upon the processing power and cost of computers:

![Moore's Law Table](image)

As Moore's Law continued to relentlessly churn, things evolved rapidly. In the mid-80s, we saw the first appearance of the “portable” or “luggable” computer. These
machines were bulky and more than occasionally unreliable. The funny things was, that while the technology that made portable computing possible had existed for some time, it would be several years more before the enormous potential for increased productivity would be really understood and utilized. Once again demonstrating that it takes years for the thinking to catch up with the technology.

And now, here we are in the new millennium, we’ve finally caught up to the present. It’s very clear that the portable-computing paradigm is really beginning to hit stride. People are beginning to understand the incredible potential contained in what is now the equivalent to a mainframe computer sitting on your lap. Portable everything has become the norm.

However, even though this stuff is powerful and amazing, we haven’t got time to relax, because as we get comfortable with this stuff, new generations of technology continue to rapidly appear. At any one time, there are probably 3 to 5 generations of technology already in the pipeline that just haven’t got here yet. In fact, the technology that you will be using in the next 10 years has probably already been invented - you just can’t buy it yet. This is due in large part to Moore’s Law. In 2002, the minimum configuration you could typically get was:

Moore's Law

![Twice the power for half the price every 18 months](image)

However, it doesn’t stop there. In a recent interview in Time magazine, Gordon Moore suggested that there is absolutely no indication that the rate of doubling will diminish for at least 10 to 15 years. This suggests that the technological transformations of the past 5 decades will be absolutely dwarfed by the changes of the next few years. If this is the case, extrapolating out to the year 2015 (when students who are presently entering the primary grades will graduate from school) the impact of the doubling becomes so incredible as to be almost unbelievable...
When you look at the table, do you find it hard to believe us? We don't believe us either sometimes. But think back to the first Hewlett Packard calculator from the earlier 70s that cost $795 – so clunky you had to use a wheelbarrow to move it around. It had the ability to add 3 digit numbers as long as it didn't have to carry. Now calculators are so tiny and common they're given away in cereal boxes.

It's important to understand that in times of radical change such as these, it's critical that you consciously force yourself to step back from the technology so that you can get a better sense of the bigger picture. Standing back, it becomes clear that we cannot view any technology outside of the continuum from past to future – from where its come from to where it's heading. The power of exponential growth means that new technological paradigms are now appearing before the previous paradigms have been properly implemented or even fully understood. The Apple II computer was sold for more than 10 years. Now the renewal cycles for most new technologies are often calculated in terms of months or weeks rather than years. As a result, when we consider a “new” piece of technology, it's important to keep in mind that in all likelihood, there are 3 or 4 newer generations of the same technology that have already appeared or are on their way.

And let's add to this what Ray Kurzweil says in his amazing book The Age of Spiritual Machines and his new book The Singularity is Near. Kurzweil's Law of Accelerating Returns says that as Moore's Law starts to diminish, it will be superceded by nanotechnology, 3 dimensional chip designs, DNA & biologically based computing that will increase speeds by a factor of many millions.

You can't view any development just for what it is today. You need to view it is part of the continuum of where it has come from to where it's heading. And this compels us to look at things differently.

**Time to ask a question.**
Do these powerful technologies - does looking at a computer screen or using a handheld, change the type of reading & writing skills we need. If so, what have we done to change the curriculum to reflect this?

Trend #2: The Law of the Photon
Consider for a moment: how fast is fast? Does anyone remember using a 1200, 2400 or 9600 baud modem? (Please, no one laugh hysterically). When you jump to 28.8 or 56K modems, the speed increase is pretty incredible. How about a cable modems chugging along at 10 megabits per second - that’s a CD-ROM in 60 seconds. A CD-ROM represents a person typing at 100 words a minute, 60 minutes an hour (this is fantasy!), 8 hours a day, 5 days a week, 52 weeks a year, for more than 12 years (Lucent commercial). Is that fast?

What about fiber optics - 10 gigabytes of information per second traveling down a single strand of glass fiber using the principles of photonics - laser light of different colors and frequencies - that’s 3 CDs per second. To put that into perspective, that’s everything that Shakespeare has ever written (he hasn’t written a lot lately has he?) translated into 200 languages and sent from New York to Los Angeles in .0043 seconds. (Lucent commercial)

Is that fast? Well, in the past 3 months, two companies (Alcatel and NEC), have separately announced speeds in excess of 10 trillion bits per second or 1,900 CDs per second down one single strand of third generation hollow glass fiber.

That’s 1900 CDs per second - 150 million simultaneous phone calls - 400,000 DVD quality movies or the entire 135 million plus items contained in the Library of Congress down 1 strand in one second. And remember, there are 800 strands to a single fiber-optic cable.

But if you think that this is fast, you need to get over it. George Gilder, a widely respected and quoted futurist from New England has written a new book entitled Telecosm. In it, he says that we need to deal with the Law of the Photon, which tells us that since 1983, bandwidth speed and capacity per dollar has been tripling every 12 months (actually it’s every 6 months, but let’s not quibble). This means that bandwidth speed is growing 3 times faster than computers) - this is resulting in the cost of sending data long distance falling by 50% per year.

Gilder further asserts that this tripling will continue for another 20 years. If it does this, bandwidth speed will increase during that span by in excess of 1 billion
times. If this is the case (and there is little reason to doubt that it isn't) this means that today we are literally in the Stone Ages of optical communications.

And that doesn't even begin to discuss the growing power of wireless. The US FTC has just approved the use of Ultra Wideband. What this means is close to fiber speed wireless through the air continuously. The Internet will be everywhere - perpetually connected - which will lead to an absolute explosion of new portable technologies & services beyond our imagination.

Stand back for a moment and consider this: fiber, wireless and coaxial cable are truly the concrete and steel of the information highway. As a result, photonics is the near and distant future of global information economy. And while things are changing rapidly, it is safe to suggest that the technological and informational transformations of the past 10,000 years will be absolutely dwarfed by the transformations we will experience in the next 3 to 5 years of our lives. These changes will have a profound effect upon the way we work, the way we play, the way we communicate and particularly, the way we learn. This pushes and will continue to push our mindsets.

**Time to ask another question.**
A question - does anytime, anywhere high-speed access to information and services change in any way the skills, knowledges and habits of mind that our students will need to survive let alone thrive in this world? What different skills do they need to know - what will they need to be able to do? What are we doing in education to help prepare them for this world?

**Trend #3: The Internet Revolution!**
It's hard enough having to deal with Moore's Law. But combine this with the subsequent emergence of the Web as a commercial force in our lives. Do you remember when you could actually look at a newspaper or magazine and NOT see some gee whiz articles about the amazing potential of the Web? Do you remember when surfing was done outdoors? When Java was something you drank with milk and sugar? When you didn't have to know what the @ sign was for? When you could actually turn on a show or watch a movie and not see http:www.spend.money? It's hard to believe that our world was a simpler place a little more than 5 years ago.

But then, everything changed in the summer of '95, when using the Web went from something done by geeks to a sign of being cool. Overnight, it went from being a specialized thing done by propeller heads who spent their time waxing their modems
to get higher speeds to something deeply embedded in the public consciousness. In ’93, there were no users of Web - this was mainly because Marc Andreessen, the creator of Mosaic, which eventually became Netscape and then was bought out by AOL, had just graduated from high school. Now, according to the latest statistics (June 2002) use continues to grow at an amazing rate. There are more than 500 million regular users in 170 countries worldwide. It’s estimated that there will be 1 billion regular users by the year 2005.

First, despite the downturn in the Internet economy, the existing Web continues to expand at a phenomenal pace. In just the past 24 hours, 80,000 new users have been added, 3 million new Web pages have been uploaded, and more than 10 billion email messages have been sent (most of them to my in-box, on most of them about erectile dysfunction or breast enhancements. For perspective, in 1990 there were 15-million email boxes worldwide. Now there are more than 400 million email boxes in the US alone. This is more email boxes than telephones, than TVs, than people. Email use is estimated (Oracle ad) growing at 1,000 times the rate of conventional mail. Access to the Web combined with use of email has lead to a fundamentally new mindset for many people.

Conservatively, in terms of pages of content and Internet traffic, despite the decline in Internet e-commerce, it’s estimated that the Web is doubling in size every 120 days, which means that conservatively it is doubling in size 3 times per year! If this is the case, more than 80% of the sites that will be existing a year from now don’t exist today. This is absolutely stupendous, biological growth-like bacteria or disease.

According to a recent study, more than 60% of American homes are on-line - more than 70% of homes with children - 74%v of homes with children. It’s estimated that 38% of users are on line for 5 hours or more weekly and that at any one time, 1 in 4 are buying something.

In another recent study, given a choice of six media, 1/3 (33%) of children aged 8 to 17 told the researcher that the Web would be the medium they would want if they could have only one medium. (TV was picked by 26%, telephone by 21% and radio by 15%).

Things are growing and changing so quickly, that we have to start viewing developments in dog years. One year of Web development is the same as 7 in almost any other medium. If we measure Web development by this standard, it’s been more than 2 centuries since the Internet was born, more than 60 years since the
emergence of the Web; and by the year 2004 the Web will have undergone another
decade of growth and development.

Until recently, cyberspace was only for propeller heads who spent their lives
sitting in the ethereal glow of a computer screen getting a great tan while drinking
Jolt Cola and eating Hostess Twinkies. Now, it’s a middle class suburb. And the
amazing thing is that this has happened in a world where it’s still going to cost you
$1,000 by the time you’ve bought your computer, modem, software and service
access; and where downloading files is, as Jim Hargreaves, David Thornburg and
many others suggest, literally like trying to suck peanut butter up a straw.

Again, we understand that we can’t view things just for what they are today, but
must see it as a continuum from the past to the future. Let’s stand back for a
moment and consider where things will go tomorrow when we see the appearance of
little $500 network and handheld devices in combination with new products and
services, and growing awareness of the power and potential of on-line
communications. Where do you think that usage is going to go? Is it going to go
down or is it going to go up? Not to use the intelligent Web will be a little like
refusing to use a car or a telephone. This helps explain Internet fever.

Look, we still aren’t there yet. There’s lots of criticism about slowness, security,
under/over regulation, and system overload. But we need to get over it. These things
will eventually be resolved. What we are experiencing with the Internet right now
is no different than what our parents, grandparents and great grandparents
experience with the early phone system. Just like the early telephone system, things
aren’t perfect yet, not all have the necessary access, it’s not always easy to
use...but despite all of the "yeah buts", this thing is coming at us like a freight
train. In a very short period, it has reached full-fledged status as a commercial
medium.

And just like the telephone, television and radio were separately the dominant media
of communication in the 20th century, when you put them together, you get the
Internet, which will probably be the dominant communications medium for the next
century. As MIT’s Nicholas Negroponte suggests, a veritable 10.5 on the Richter
scale of social significance - and so, it’s almost impossible to overstate its
importance. Then combine this with rapidly increasing bandwidth speeds.

Time to ask another question.
Do you write differently online with email or Instant Messenger than you were
taught to write when you were in school? Is so, what have we done to change the
English/Language Arts curriculum in schools today to reflect those changes? Alternatively, are we still pretty much teaching the same curriculum that we were taught?

**Trend #4: The Age of InfoWhelm**

According to George Gilder, we live in the age of disposable information, where even the daily newspaper arrives with the faint odor of obsolescence.

Directly because of computers, growing bandwidth and networks, the number of words, terms, concepts generated are growing at an exponential rate. Looking at this in real terms, there are estimated to be about 540,000 words in the English language, which is about 5 times as many as there were in Shakespeare’s time. As a result today we are dealing with a raging torrent of information. It's estimated that there was more new data produced in the last 50 years than in the previous 5,000 years. More than 3,000 books published daily which explains why we feel so inadequate when someone asks us if we've read a new book and we haven’t even heard of the writer.

Futurist Richard Saul Wurman, in his book *Information Anxiety*, stated that a weekly edition of the *New York Times* contains more information that a person was likely to come across in a lifetime in the 18th Century. He estimated that in one year a person will read or complete 3,000 notices and forms, read newspapers and magazines for 234 hours, watch 1,571 hours of television, listen to 1,056 hours of radio, listen to 269 hours of recorded music, talk on the phone for 361 hours, go online for 43 hours and read books for 96 hours.

In essence, we spend most of our lives working and exchanging information in some form. Michael Crichton, author of *Jurassic Park* suggests that the average adult today spends more money on food for thought than on food for the body.

Gilder says that if we were to take the sum total or recorded wisdom knowledge and data from the beginning of recorded history to 1992 and viewed that as a ball of twine, that between 1992 and today (primarily because of powerful new technologies combined with expanding global digital networks together with wired and wireless bandwidth, that ball of twine would have increased in size by 20 times.

Gilder estimates that the amount of unique new technical information in our world is doubling every 2 years. He estimates that it will be doubling every two weeks by the year 2005. Gilder says that this trend has lead to a fundamental depreciation in
the value of technical information. He asserts that if you were to take a student who had graduated from your local high school last year, and put them into a 4 year technical degree, that half of what they learned in their first year would be outdated, obsolete or just plain wrong by the beginning of their third year. The half-life of knowledge depreciation for an engineer is 3 years. For a biochemist or doctor, it’s two years. Under those circumstances, what’s your own personal rate of depreciation?

A recent study from the University of California at Berkeley states that the amount of unique information being generated is beyond our ability to comprehend. It estimates that 1.5 exabytes of unique new information is generated worldwide each year - an exabyte is a 1 followed by 18 zeroes - 1,000,000,000,000,000,000 bytes of information. If this were stored on floppy disks, storing the information would require a stack of floppy disks 2 million miles high.

That translates into a library of 250 books for every man, woman & child on the planet. It’s estimated that 93% of this information is stored digitally and that anyone connected to the Internet will soon be able to gain access to virtually all of it.

**Time to ask another question.**

Information technology has changed everything we do with communication technology. So what do we read on line - novels, essays, and poems? Maybe, but this is not likely. How about charts, graphs, graphics, and spreadsheets. Is this the same or different than literary reading? It’s different - this is technical reading - which uses a completely different cognitive process. So, how are we modifying our curriculum to prepare our students for this type of reading? Or are we just continuing to do what we’ve always done?

**Trend #5: Biotechnology**

Biotechnology is the use of biological processes to develop products or create technological solutions to problems. Biotechnology is used in many fields including pharmacology, medicine, agriculture, and mining. The first forms of biotechnology were bread making, cheese making, wine making and beer making. Today biotechnology is used to create antibiotics, insulin, and interferon to name but a few of many. In the past few years, we’ve even see the emergence of pharming where genetically engineered animals are used to create medically useful substances and body parts.
The Human Genome Project

In the early 1990s, the Human Genome Project was begun. The project was designed to find the locations of the 40,000 genes and 3 billion nucleotide bases (or combinations of genes) that make up the human genetic structure. The goal of the project was to create a road map to the entire genetic script of humans and in doing so, to identify the genes responsible for 3,000 to 4,000 hereditary diseases such as Huntington's, cystic fibrosis and muscular dystrophy; as well as to identify the genes known to play a part in cancer, heart disease, diabetes, Alzheimers and many other common diseases.

In completing a map, scientists hoped to create tools, therapies and targeted drugs to act on the causes, not just the symptoms of diseases. Now you need to understand that this is an incredibly complex task, representing billions of bits of information - enough information to fill 1000 1000-page telephone books. This project was initially expected to take until 2005, but the first map was actually completed in June of 2000.

Why did this happen so quickly?
In large part it was because of the incredible computational processing power that has resulted from Moore’s Law and the rest of the exponential trends outlined here.

Translating the table, in 1983 it took 6 people working a total of 3300 man days to identify 4000 nucleotides (gene combinations) - an average of 1.2 combinations a day. By 1998, in large part due in very large part to the powerful new technologies, it took one person 8 hours to identify 50,000 nucleotides - an average of more than 17 per second. Today it takes one person two minutes to identify 50,000 nucleotides - an average of more than 417 per second. And by 2005, it's estimated that it will take one person 10 seconds to identify 50,000 nucleotides - the entire human genome in 10 seconds - an average of more than 5000 per second.
And now that the Human Genome Project is well in hand, we are now at the very beginning of the Human Proteome Project. By way of background, genes are just the blueprints for creating proteins. The Number of genes is approximately 40,000 in about 3 billion combinations. The number of proteins is estimated in the hundreds of thousands if not millions, with trillions of combinations. This will be a huge task, but exponentialism will in due course reveal the secrets of proteins, allowing the creation of even more sophisticated tools, therapies and targeted drugs that can be customized to meet the needs of the individual patient. The next ten years are going to be amazing.

**Time to ask another question.**

How are the latest developments in biotechnology being represented in the current Math and Science curricula? What have we changed to reflect the new reality of biotechnology?

**Trend #6: Nanotechnology**

Do you remember the old days - way back in the 70’s when you bought component stereos - what did you buy? An amp? A pre-amp? Speakers? A tape deck? A record player (Daddy, what's a record player?) - if you were really insecure like I was, you also bought a long extension cord and some duct tape and put them all together so you could go down to the beach to impress people.

Then in the early 80’s came the Boom Box. The Boom Box was a technological cybrid - a fusing together of what had previously been separate devices. What also came was the unanticipated power that comes with the synergy of combined technologies. Because of Moore’s Law, this convergence continues. These devices are already doubling in power & at same time getting smaller and smaller, which means we can now place more & more devices together onto a smaller & smaller piece of electronic real estate. It’s miniaturization & convergence that have lead to portability & the appearance of anytime/anywhere technology. However, let’s step for a moment to consider the continuum from back there to out here.
Consider IBM’s 305 RAMAC.

On September 13, 1956, a team of IBM engineers in San Jose introduced the first computer disk storage system. The 305 RAMAC (Random Access Method of Accounting and Control) could store five million characters (five megabytes) of data on 50 disks, each 24 inches in diameter. The first hard drive occupied the space of two refrigerators. It stored the data on 50 hefty aluminum disks coated on both sides with a magnetic iron oxide, the same paint used on the Golden Gate Bridge. The RAMAC weighed more than a ton.

Now compare the RAMAC to the new IBM 1 Gig micro-drive that is literally the size of a hamster. Ten years ago, a 1 Gig hard drive would have been the size of a freezer. Fifty years ago, it would have been the size of Argentina. Looking at this another way, because of miniaturization, today’s average consumers wear more computing power on their wrists than existed in the entire world before 1961.

To put things in context, consider...

The Eniac computer.
The Eniac was the first digital computer. It was built between 1943 and 1946 at the University of Pennsylvania. It was used to calculate firing tables for cannons. The Eniac was a building based computer. It had two floors - one floor just for the computer, another floor just for the cooling system. It weighed 30 tons - stood 8' high - and was the length of two tractor-trailers. It cost $750,000 in 1946 dollars. It had 5 million soldered connections, 70,000 resistors, 10,000 capacitors, 1,500 relays, and 6,000 manual switches. Creating a program could take several days of switch flipping and wire plugging 17,000 vacuum tubes. Moths were a particular pest because of their attraction to the glowing vacuum tubes. They would flit about often getting fried on the tubes or zapped on the wiring. The first technicians positively proved that they had solved the computer glitch by taping the offending bug to their logbooks beside the entry describing the problem. The Eniac consumed 160,000 Watts of electrical power, making the lights go dim in Philadelphia each time it was powered up and typically lasted about 7 minutes between breakdowns.

But at the same time, the people who were using it just couldn't believe their eyes. Because the Eniac could do 5000 calculations per second - taking a ten-digit number and multiplying it by another ten digit number in 3/1000ths of a second. Even though by our standards today the Eniac is clunky & unreliable, it was a huge jump forward in computational power. Who could have imagined in the time of the Eniac that this was going to lead to cell phones, satellites, Nintendo, and all of the other digital wonders in our world? With this in mind, now consider:

Microtechnology.

This is prototype chip from Intel. This is microtechnology. It's 1/3" long. Hard to believe, but it actually could be smaller, but as it is you could accidentally inhale it and probably not realize that you had done it. Yet, this tiny chip is 10 million times more powerful than the building based Eniac computer from 1946.

Today the focus is on microtechnology, Tomorrow the focus will be on:
Nanotechnology
Nanotechnology is not about building things down by making them smaller and smaller but building things up by manipulating one atom at a time as was first done by IBM several years ago when they used 35 precisely placed Xenon atoms to spell out the IBM logo:

![IBM logo spelt out by Xenon atoms](image)

Nanotechnology will be used first to create nano machines and nanobots and then in due course, to create self-replicating. These devices will be created to reverse engineer human processes and duplicate designs from nature to remove plague from the bloodstream, target cancer cells, perform non-invasive surgery, and other services beyond our imagination - and this will begin to happen within 5 years. Think about the Incredible Voyage with Raquel Welch or Innerspace with Dennis Quaid - the mind boggles!

Just imagine what would happen if we were able to take one of today's middle of the road laptop or handheld computers, give it to someone (we'd want it back) and put them in a time machine and send them back to the Eniac lab in 1946 to show the technicians there what would had. What would they think?

Looking to the Future
So where do things go from here? Harvey Long once said that those who live by the crystal ball usually ending up eating crushed glass. It's hard to accurately anticipate the future when you live in a world of fundamental uncertainty. Nevertheless, we must try. We all need to start thinking in future tense - to live life like a quarterback. A quarterback must be a futurist - learning to throw the ball not to where the receiver is, but to where the receiver is going to be. It's much the same with technology. We need to be looking ahead, considering where things might go 3, 4 even 5 generations down the road.

The future possibilities are absolutely amazing. Miniaturized electronics built at the micron level; palmtop technologies effortlessly connected to the global digital network; the ability to fax three-dimensional objects; molecular- and bacteria-based computers; new cyborg controls; remarkable new implant technologies and body
transceivers; intelligent pacemakers; biofeedback technology; thought control computing; virtual experiences; and virtual existence – all of these and much, much more are in our immediate future. These will be remarkable new devices that create potential for amazing new possibilities.

But are we becoming the Borg? We will become the computer at the point when the power of the computer can no longer be viewed in isolation from humankind. Increasingly, we will live in an anytime, anywhere world where if you’re not connected, you’re really won’t be computing. To really understand where we are and what we need to do, we must stand back and consider the profound implications all of these developments will have for education. And as always, mindset will be the key to bringing the many possibilities to reality.

Okay, let’s stop for a moment and take a deep breath - I suspect that many of you are convinced I’ve gone right over the edge - many of you are convinced that this will never happen - that the medication must be wearing off. Our friend David Thornburg once said that the difference between science fiction and reality is that science fiction must be believable. That’s because much of the reality coming down the pipeline at us right now is absolutely unbelievable. And while things may not turn out exactly like they have been described here, the bottom line is that these new technologies and their accompanying mindsets are coming at us like an absolute tidal wave. Without doubt, tomorrow’s student will use voice-activated or thought-activated computers that will be directly connected to global digital networks through such things as body-implant transceivers, wearable computers and transplanted cornea virtual retinal displays. Stuff that’s worth a fortune or not even available today will be on the clearance table at Wal-Mart tomorrow.

So how will teachers react when this stuff starts appearing in kids’ backpacks? Before we consider that, let’s reflect back to what happened when the first ballpoint pens started appearing in classes back in the 40s. We banned them. When the first calculators showed up in the early 70s? We banned them. When the first student assignment appeared on a disk in the 80s? We refused to accept it. The bottom line is that this is all about mindset. So how will teachers react when the first Borg walks into the classroom? Will we be banning the kids? Will we be telling them to “stop thinking that,” “stop being that” or “stop going there”?

Stand back! Our job is to stop and consider what this means for education. That’s because, for education and educators, the treadmill appears to keep getting steeper and steeper; and faster and faster. It’s becoming increasingly harder to keep up with the radical changes that we are being confronted with each and every day.
Does this mean that the situation is hopeless? The answer to that question is absolutely yes... if the focus continues to be on the acquisition of technology - because we in education just haven't got the financial or emotional wherewithal to keep up. So the critical question that must be asked is “What should our focus be when these kids walk into our classrooms?” How will these new technologies change the way we view curriculum and learning? Are there principles and processes that transcend the new technologies and the proliferation of new technological paradigms?

The answer to these and many other questions is that it’s all about making the move to transcendental teaching. The answers are founded on the development of a new educational paradigm that makes the fundamental shift from a content-based curriculum to a process-based curriculum. This is a curriculum that emphasizes the process of learning rather than just the product of learning. A new paradigm that focuses on the transparent usage of technology rather than on just the tool - on information fluency - on critical thinking and problem solving skills - and on real world communication skills. It’s all about moving technology from being a toy to being a tool. The bottom line is that technology is not a subject or curriculum, it’s a process - so the critical issues we must consider are far less to do with hardware, that they are to do with headware. It’s about organizing technology around student learning; not student learning being organized around technology. And our job as educators is to step back and consider where and how this stuff all fits together - but to do this we must understand that it’s not the tool, it’s the task that must take center stage.

Will this all really happen? It’s not a matter of IF but of WHEN. And the message to all educators is that it’s time to get over it and get on with making the necessary changes before it’s too late. The bottom line is that we must move quickly or otherwise the market will find its educational experiences elsewhere. It’s this that should be pushing our mindset!

What we are dealing with are matters of inner space. In the 21st Century, you will be what you think because the new frontier is a mental one, not a physical one. Our greatest challenge is to comprehend the magnitude of the changes that will be necessary. As we move through the 21st Century be certain that the biggest challenge will be to continually let go of your current mindset. This process starts and ends with us. What’s our job? As David Thornburg says, “to prepare kids for their future rather than our past or present.” We need to start by retooling our minds.
“Change is the law of life... those who look only to the past or the present are certain to miss the future.” – John F. Kennedy

We are beginning to grasp that although power can be contained in a boiler, mastery exists only in the brain: in other words, that it is ideas, not locomotives, that move the world. To harness locomotives to the ideas is good; but do not let us mistake the horse for the rider,” – Victor Hugo, (Les Misérables), 1862

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