

Symbiotic Intelligence

With Technology, Humans will attain a new level of symbiotic life in the 21st century

Chaos 2000
Santa Fe
Thursday, May 4, '00

Jim Pinto
San Diego, CA.
jim@JimPinto.com
www.JimPinto.com

The Age of Complexity Science

“I am convinced that the nations and people who master the new sciences of complexity will become the economic, cultural and political super-powers of the next century”

- Heinz Pagels
“The Dreams of Reason”

“I think the next century will be the century of complexity.”

- Stephen Hawking

“We stand on the verge of being able to change the human race”

- Wired Magazine
January '98

Evolution - from Chemistry to Biology



2 billion years after Earth was formed - life began
Patterns of matter and energy that could perpetuate themselves, did

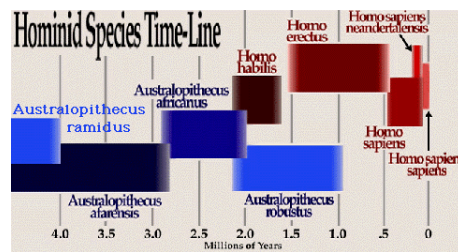
With Time, the patterns became more complicated
- from Chemistry to Biology.

A key element of an evolutionary process is a
“written record” - otherwise it would be doomed to repeat.

DNA - the digital computer designed by Evolution
to record its handiwork.

Evolution - Time Speeding Up

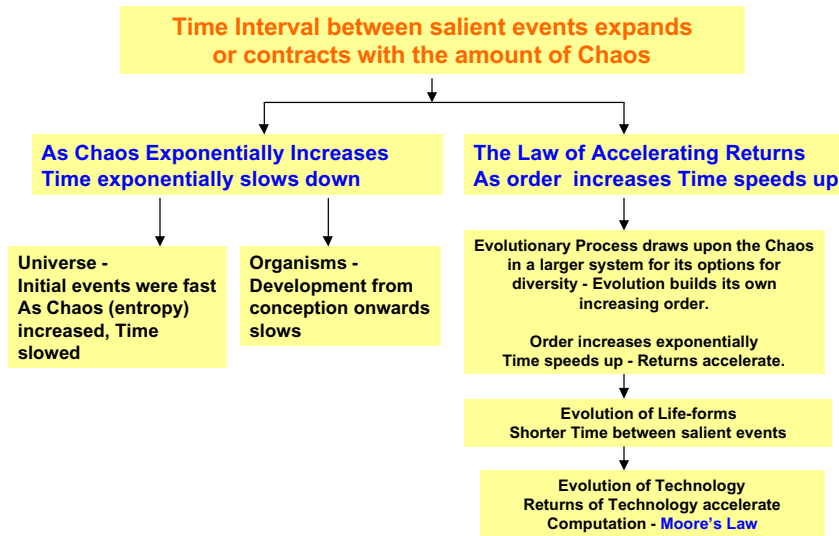
Evolution took billions of years to design the first primitive cells - and then events took only hundreds of millions of years



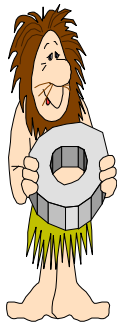
- Dinosaurs - 65 million years ago
- Primates - Tens of millions of years.
- Humanoids - 5 millions years ago
- Homo Sapiens - 0.5 million years ago

DNA is 98.6% the same as the gorilla, and 97.8% the same as orangutans.

The Law of Time and Chaos



Technology - Evolution by Other Means



Homo Sapiens - distinguished by *invention* of technology.

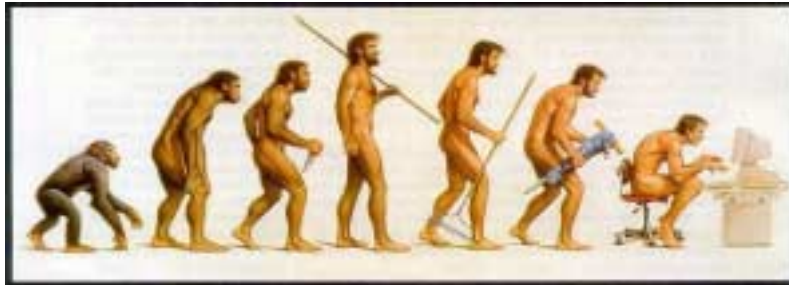
Technology - a continuation of Evolution

- beyond the making and use of tools
- record and progression in sophistication
- requires invention..

Multiple subspecies of Homo Sapiens - the technologically more advanced groups became dominant.

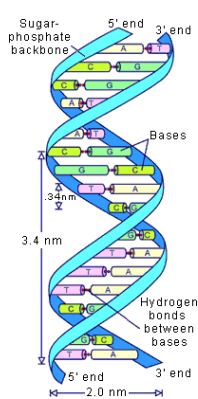
Evolution - Selection through Survival.

Technology - Extension of Evolution



Evolution - Inefficient Programmer

Evolution is a very inefficient programmer



- ◆ Most of the code “does not compute”
- ◆ Most of the DNA sequences do not produce proteins.
- ◆ 97% of the code is useless.
- ◆ Active part of the code is only about 23 megabytes (less than Microsoft Word)
- ◆ Only object code, no source code
- ◆ No programming manual, no help files, no user manual.
- ◆ Introduce changes (updates) only at random
- ◆ Changes are evaluated over time by survival, and ability to reproduce.
- ◆ Survival appears to be a crude technique - focussing on a few features at a time
- ◆ Evolution cannot easily perform complete re-designs
It is stuck - in time.

The IQ Of Evolution

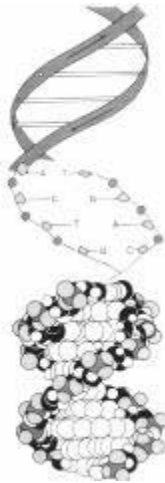
Evolution has produced millions of designs.
Deficiency - it is very slow!

Most IQ tests are timed.
The IQ of Evolution is infinitesimally above zero
- only a bit smarter than random behaviors.

The reason that our human-sponsored evolution is
“smarter” is that we speed up time.

The Question : Can Human intelligence create an
intelligence more intelligent than itself?

The Hardware & Software of Evolution



Software recorded as digital data in the chemical structure of an ingenious molecule called **deoxyribonucleic acid** - DNA - the read-only memory (ROM) that controls the vast machinery of life. Remarkably complex and amazingly simple - Only four basic pairs provide the data storage for the complexity of all the millions of life-forms on earth, from primitive bacteria to human beings.

The ribosomes - little recorder modules - read the code and build proteins from only 20 amino acids. Everything is programmed from this efficient code!

This is “*nano-engineering*” - the machinery of life takes place on the atomic level.

The 3 Technology Laws

- **Moore's Law**
Processing power doubles every 18 months
- **Gilders's Law**
Bandwidth doubles every 12 months
- **Metcalfe's Law**
Effectiveness increases exponentially with the number of connections

All 3 laws predict exponential advances

The Law of Accelerating Returns

“As order increases, so Time speeds up.”

Where does this leave Moore's Law?
Dead (or on the way out) by 2020 -
but another computational technology will pick up where
Moore's Law left off, without missing a beat!

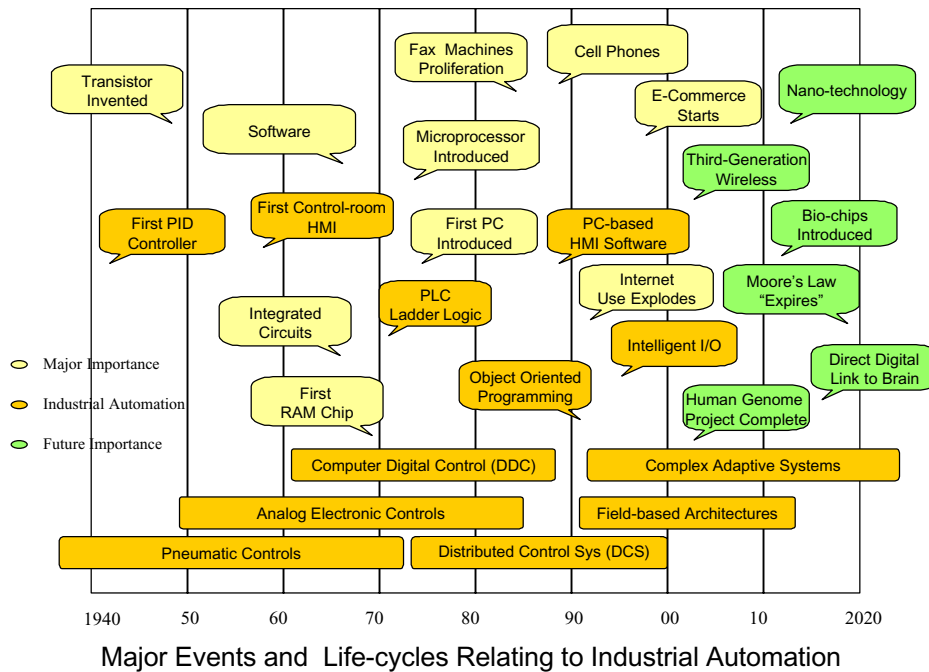
Most exponential trends hit a wall - not this one!

The Inventor of Chess and the Emperor of China
- at the start of the next century, we are in the second half of
the chess board.

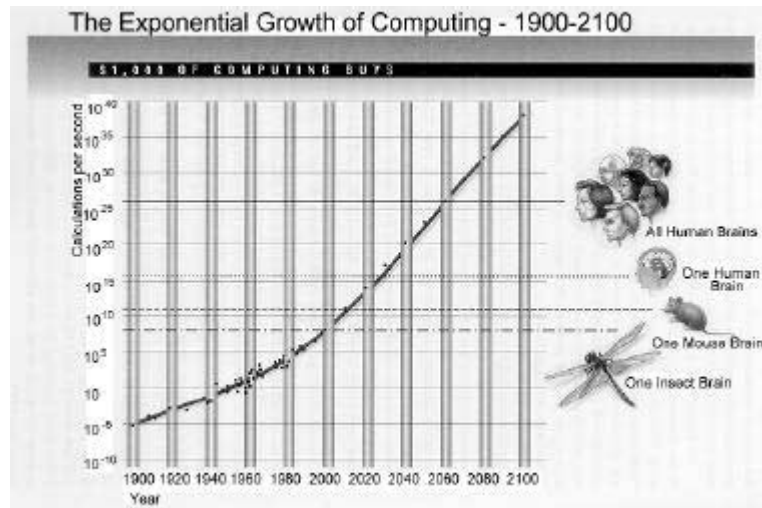
Technology - Accelerated Evolution

Technology, like Evolution that spawned it - is inherently an accelerating process.

- Mechanical (Tools) - millennia
- Machines (human operated) - centuries
- Automatic Machines - century
- Electromechanical (Relays) - decades
- Electronic (Vacuum Tubes) - decades
- Transistors (Solid-state) - decades
- Integrated Circuits - leading to Moore's Law - decades
- Pervasive Wireless communications - decade
- Bio-chips, Nano-technology - future (decade)



Growth of Computing : 1900-2100



The Hardware of Intelligence

Human brain - massive parallelism is the strength.
Slow speed is the weakness.

DNA-based evolution will eventually need to be abandoned.
Too plodding. Good at tinkering and extending, but unable to scrap a design and start-over.

The Law of Accelerating Returns says that Evolution will not be stuck - indeed it will find a way around limitations of neural circuits - humans have invented a technology that is a million times faster than carbon-based neurons. Ultimately, we'll port everything to faster equivalents.

The Software of Intelligence

What is needed to build intelligent machines :

- Right set of formulas - recursive search, self-organizing neural nets, evolutionary improvement algorithms.
- Knowledge - something to start with - the rest can be learned by exposure.
- Computation.

Beyond Silicon



MIT - Technology Review - May/June 2000

<http://www.techreview.com/>

The End of Moore's Law

<http://www.techreview.com/articles/may00/mann.htm>

Molecular Computing

<http://www.techreview.com/articles/may00/rotman.htm>

Quantum Computing

<http://www.techreview.com/articles/may00/waldrop.htm>

Biological Computing

<http://www.techreview.com/articles/may00/garfinkel.htm>

DNA Computing

<http://www.techreview.com/articles/may00/regalado.htm>

Computing Substrates in the 21st Century



Standard IC methodology will get close to human brain by 2020.
Including 3-dimensional ICs - **Cubic Memory, Dense-Pac, Staktek.**

Computing with Light - **Quanta Image, Photonics, Mytec** - optical computing - calculations performed in parallel by optical elements. Massive parallelism makes it good for things like pattern recognition.



Molecular Computing - Harnessing the DNA molecule as a practical computing device.

Nanotubes - elongated carbon molecules that look like tubes. Become conductors or semi-conductors dependent on the shape. Only 1 atom thick. Can be assembled in 3-dimensional arrays. Far denser than the human brain.



Quantum Computers - Qu-bits - each bit is 0 and 1 at the same time, with a probability.

Achieving the Hardware Capacity of the Human Brain

Human brain - 100 billion neurons - estimated 1,000 connections between each neuron and its neighbors, 100 trillion connections, each capable of simultaneous calculation. However - only 200 calculations per second. For problems requiring massive parallelism (like pattern recognition) this is great. But, for extensive sequential thinking, the is is mediocre.



100 trillion connections - each 200 calcs per sec - 20 million billion calcs/sec. So, when will we see equivalent speed ?

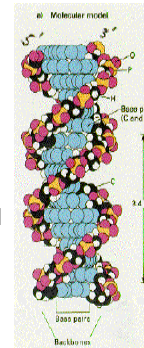
The Human Genome Project



International research program with the goal of gathering a resource of genome maps and DNA sequence information that will provide detailed information about the structure, organization and characteristics of the DNA of humans and other animals.

The project began in the mid-80's and is expected to be complete by around 2003 (18-20 years)

<http://www.mcet.edu/genome/>
<http://www.nhgri.nih.gov/>



The Human Genome Project



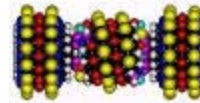
Decoding the Human Body
By Sharon Begley
Newsweek, April 10, 2000

<http://newsweek.com/nw-srv/printed/us/st/a18147-2000apr2.htm>



Nano-Engineering

K. Eric Drexler - founding father of “**nano-technology**”,
Use individual atoms & molecules to build machines.
Institute for Molecular Manufacturing: <http://www.imm.org/>



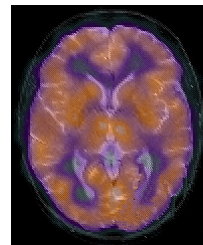
If you can engineer DNA on a molecular level, why not build machines out of atoms, program them to build more machines, and so on - until you have millions of infinitesimal “nanobots” - endlessly restocking the food supply, or swarming through the bloodstream eradicating disease, or building skyscrapers from industrial waste? If “nanotech” is viable, it promises a gleaming future of virtually limitless wealth and endlessly renewable resources.

Engines of Creation - Drexler (1986)

*Nanosystems: Molecular Machinery, Manufacturing and Computation
Wiley Interscience (1992)*

Reverse Engineering the Human Brain

We can do a detailed brain scan
- to understand it.
Within a region, a brain is highly repetitive
- so we need to only scan a portion.



Downloading your mind to a personal computer.
What will we find when we really do this?

In the 21st century there will be growing trend to do this.

The age of neural implants has already started.

What is mortality? If you are “backed up” how can you be “dead” ?

Human or Machine?

Is a human with mechanical implants a machine?
Is a machine with human extensions a human?

How do you “experience” color?
Are animals more human? Or machine?
When does a fetus achieve consciousness?

Consciousness is a Being Reflecting on Itself
- I think therefore I am.

Different Schools of Thought

- **“Consciousness is different kind of stuff”**
- **“We can’t understand”**
- **“Thinking is as Thinking does”**



Deep Blue vs Kasparov



“As Deep Blue goes deeper and deeper, it displays elements of strategic understanding. Somewhere out there, mere tactics are translating into strategy. This is the closest thing I’ve seen to computer intelligence. It’s a weird form of intelligence. But, you can feel it. You can smell it!”

Frederick Friedel, assistant to Gary Kasparov, commenting on the computer that beat his boss.

Intelligence - The Recursive Formula

Pruning the possibilities, stopping the recursive growth of the tree of possibilities.

Humans advancing by almost zero - computer recursive depth capabilities doubling each year. You could predict when the computer would beat a human at Chess (97/98).

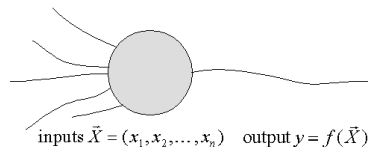
Recursion is suited only to problems with well defined rules. Games, music, poetry (especially rhymes). Kurzweils Cybernetic Poet uses a recursive approach - with limited success.

Intelligence - Neural Nets

Attempt to emulate the computing structure of neurons in the human brain:

- a/ Set of inputs that represent the problem to be solved;
- b/ Inputs randomly wired to a layer of simulated neurons;
- c/ Each connection has a strength (initially set at random);

Starts out ignorant, and "learns".
Connections that "help" the right answer are made stronger, connections that "hurt" are made weaker.



Neural nets are good at pattern recognition types of problems.

Elimination of Information - the key to intelligence - reducing thousands of inputs to an intelligent output, and discarding the rest.

<http://www.calresco.org/neural.htm>

Intelligence - Evolutionary (Genetic) Algorithms

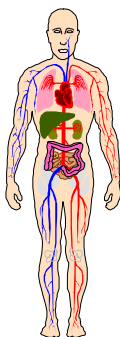
Originated by John Holland - early 70's.

Solutions are not programmed - they emerge through an iterative process of simulated competition and improvement. Smart but slow - retains the discernment of Evolution - but useful if speeded up a million fold.

Genetic Algorithms are used to solve otherwise intractable business problems. Example - stock-market : Generate a million rules for making investment decisions. Kill off the ones that are unsuccessful. You're left with the ones that are successful. Several successful investment funds are making decisions this way. \$ 95billion being invested today.

<http://www.calresco.org/genetic.htm>

21st Century Bodies



Body and Brain will be enhanced together.

Enhancing bodies cell by cell
Nano technology - building atom by atom

Building replicas - the Blob

Morphing in the real world - self-replicating at the atom level. What happens if we fail to halt the self-replication?

Hey, why do we need bodies?
Virtual bodies?

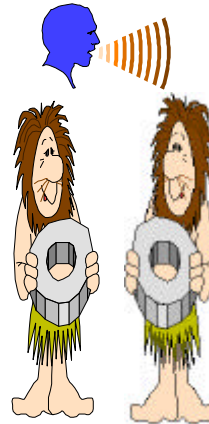
The **Sensual** Machine



Can Intelligent Systems Become Self-Organizing ??

- The essential ingredients
 - Communication (network)
 - Re-programmability (by others) over the network
 - Ability to change “behavior” (self-re-programming)

Based on external or internal stimuli/algorithms



Internet - Emergent Properties

Rules :



- 1/ Everyone uses the same protocol (TCP/IP)
- 2/ Standardized packets, moving chaotically
- 3/ Users pay for their own links
- 4/ Each node contributes and benefits

Emergent Properties :

- Interconnectivity
- Intercommutability
- Intercreativity

Internet - Planetary Brain



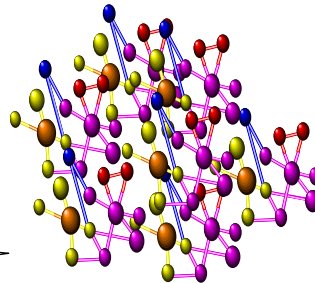
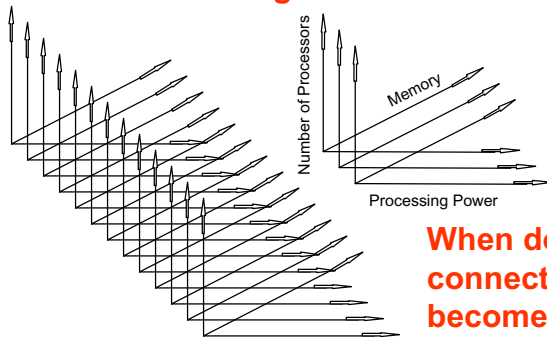
The Internet is evolving spontaneously, chaotically and autocatalytically

Each new application creates an area of complexification, amplifying the total “intelligence” of the network.

New solutions and applications appear more quickly, catalyzing the growth of the system.

Critical Complexity

When does “processing power” become “intelligence” ?



When does connected intelligence become “self-organizing” ?

Critical Complexity



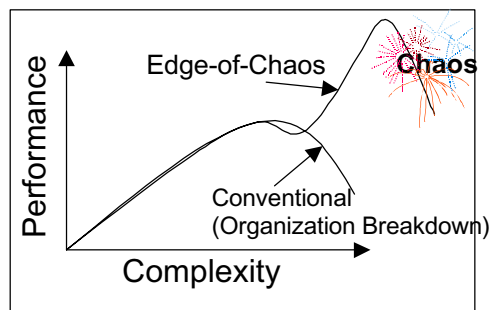
Stuart Kaufman

When a system of simple inter-acting components reaches a certain level of complexity or **inter-connectedness**, it undergoes a dramatic transition, or phase change.

The Edge of Chaos

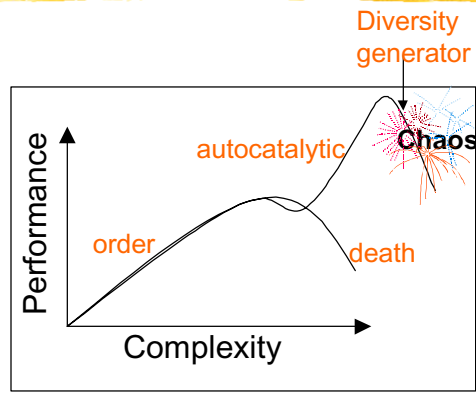
Chris Langton

A systems computational capability peaks in a narrow regime between highly periodic and chaotic behavior.

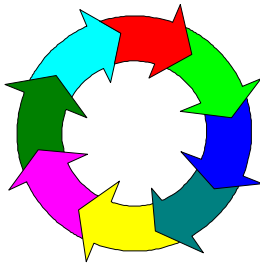


Symbionomic Evolution

- Agents
- Links
- Reproduction
- Reinforcement
- Network
- Chaos
- Amplification
- Self-selection
- Organization
- Emergence
- Transmission
- Symbiosis



Autocatalysis



The phenomenon of lock-in through “autocatalysis” and self-selection demonstrates the general process of emergence of organized complexity such as variations, mutations, catalysis, amplification, selection, stabilization, self-organization and co-evolution.

Golden-rule for breaking deadlocks in the management of complex systems :
Reversing or combining feedback loops makes the system go from one of diminishing returns to one of increasing returns.

Artificial Life - The Adaptive Organization

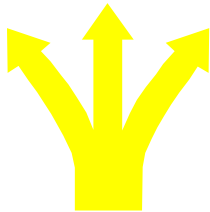
Chris Langton - “Strong A-Life”



If molecules (intelligent nodes) spontaneously organize themselves into entities that eat, reproduce, evolve (re-program, assign new tasks, change control strategies) those entities would be “**alive**”.

“**Neobiology**” : Born at Santa Fe (Chris Langton - 1987)
Synthesis of biology, chemistry, physics, robotics, computer science, ecology and anthropology

Analysis - 3 Revolutions



Industrial : Coal to Cars

Information : Writing to the Microprocessor

Biological : Mastery of DNA

The **Coevolutionary** Process

All dominated by **Analysis**

Synthesis - The revolution of Complexity Science



Where **Analysis** and **Synthesis** meet
is **Chaos**

Humanity looks to me like a
magnificent beginning
- but not the final word.
- *Freeman Dyson*

Complexity & Chaos

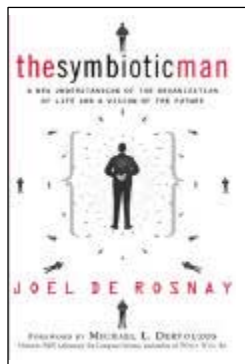


Complexity Science : The study of emergent behavior exhibited by interacting systems operating at the threshold of stability and chaos
- *William H. Roetzheim*

Artificial Life : A synthetic approach to studying Life-as-it-could-be and viewing Life-as-it-is within a larger context.
- *Chris G. Langton*

Fractals Everywhere : General laws exist that apply to areas as diverse as business, markets, large organizations, competing animal populations, insect societies, cell development, chemical reactions, virus reproduction and the formation of planets.
- *Joel de Rosnay*

The Symbiotic Man



The Symbiotic Man:

A New Understanding of the Organization of Life
and a Vision of the Future

by Joel De Rosnay

<http://194.199.143.5/derosnay/e-index.html>

We are witnessing the origin of a new life-form
on Earth - a still embryonic macro-organism made
up of the totality of human beings and machines,
living creatures, networks and nations - trying to live
in **symbiosis** with the planetary ecosystem.

Web Links

The Dreams of Reason - Heinz Pagels : <http://www.gbn.org/bookclub/Dreams.html>

Stephen Hawking on Complexity - Brief History of the Future:

<http://www.theage.com.au/news/2000/11/11/A17259-2000Jan10.html>

Moore's Law : <http://www.intel.com/intel/museum/25anniv/Hof/moore.htm>

DNA Computing : <http://www.corninfo.chem.wisc.edu/writings/DNAcomputing.html>

DNA Computers : http://www.mit.edu/research/nanotech/hapgood_on_dna.html

Blending Biology & Microelectronics : <http://www.hightechcareers.com/doc898/bio898.html>

MIT Artificial Intelligence Lab : <http://www.ai.mit.edu/>

MIT - Technology Review - May/June 2000 <http://www.techreview.com/>

Artificial Life (Santa Fe) : <http://alife.org/>

The Human Genome Project : <http://www.nhgri.nih.gov/>

Kurzweil's Technologies : <http://www.kurzweiltech.com/>

Autonomous Agents Conference 99: <http://www.cs.washington.edu/research/agents99/>

Genetic Algorithm Archive : <http://www.aic.nrl.navy.mil/galist/>

NanoTechnology - Eric Drexler Book : <http://www.foresight.org/EOC/index.html>

Molecular Manufacturing : <http://www.imm.org/>

Introduction to Neural Networks : <http://www.cs.stir.ac.uk/~lss/NNIntro/InvSlides.html>

Jim Pinto : Predictions & Possibilities : <http://www.jimpinto.com/writings/predictions.html>

Jim Pinto : Intelligence & Consciousness in the New Age :

<http://www.jimpinto.com/writings/consciousness.html>