THE BIONIC CONVERGENCE
KEVIN KELLY

The failure to create artificial intelligence in the last two decades has made it embarrassingly clear that the naked clockwork logic of machines alone cannot build a workable robot. Clockwork logic — the logic of the technos will only build simple contraptions. Truly complex systems such as a cell, a meadow, an economy, or a brain require a rigorous non-technological logic. We now see that no logic except bio-logic can assemble a thinking device, or even a workable system of any largeness.

Nature has all along yielded her flesh to humans. First, we took nature's materials as food, fibers and shelter. Then we learned to extract raw materials from nature's biosphere to create our own new synthetic materials. Now bios is yielding us her mind; we take her logic.

The most astounding discovery of the last ten years has been that one can take the logic of bios out of biology and still have something useful. Although many philosophers in the past have suspected one could abstract the laws of life and apply them elsewhere, it wasn't until the complexity of computers and human-made systems became as complicated as living things, that it was possible to prove this.

Now that scientists routinely abstract bio-logical principles from organic systems and implant them in technological systems, it's amazing how much of life can be transferred.

Among the aspects of life successfully transported to mechanical systems so far are: self-replication, self-governence, limited self-repair, mild evolution, and partial learning.

The new interdisciplinary perspective of Artificial Life interprets these successful experiments as indications that yet more of life can be ported into the mechanical. An emerging sense of the logic of bios suggests the following:
• All sustainable systems must be grown over time
• All reliable systems must be distributed in organization
• All adaptable systems must be governed from the bottom
• All innovative systems must honor errors and variation

These principles underpin the awesome workings of ecosystems, eyeballs, natural selection in geological time, and the unfolding of a baby elephant from a tiny seed of sperm and egg.

These same principles of bio-logic are now being implanted in computer chips, electronic networks, robot modules, pharmaceutical searches, software design, and styles of management, in order that these artificial systems may overcome their own complexity. When the technos is enlivened by bios we get complex mechanical systems that can adapt, learn, and even evolve. The animation of the inanimate is the foundation of artificial life and genetic art.

At the same time that the logic of bios is being imported into machines, the logic of technos is being imported into life.

The root of bioengineering is the desire to control the organic long enough to improve it. Domesticated plants and animals are example of technos-logic applied to life. The wild aromatic root of the Queen Anne's Lace weed was fine tuned over generations by selective herb gatherers until it evolved into a sweet carrot of the garden; the udders of wild bovines were selectively enlarged in a "unnatural" way to satisfy humans rather than calves. Milk

cows and carrots, therefore, are human inventions as much as steam engines and gunpowder are. But milk cows and carrots are more indicative of the kind of inventions humans will make in the future: products that are grown, rather than manufactured.

Genetic engineering is precisely what cattle breeders do when they select better strains of Holsteins, only bioengineers employ more precise and powerful control. While carrot and milk cow breeders had to rely on Darwinian evolution, modern genetic engineers can use Lamarkian evolution-purposeful design which greatly accelerates improvements.

The overlap of the mechanical and the life-like increases year by year. Part of this bionic convergence is a matter of words. The meaning of "mechanical" and the meaning of the term "life" are both stretching until all complicated things can be perceived as machines, and all self-sustaining machines can be perceived as alive.

Yet beyond semantics, two concrete trends are happening: 1) Man-made things are behaving more life-like, and 2) Life is becoming more engineered. The veil of the no-man's land between the organic and the manufactured has crumpled to reveal that the two really are, and have always been, the same place.

Some insights come from studying the complexity of large human-made systems. But the wildness of nature is the chief source for clarifying insights into large systems, and probably the paramount source of more insights to come. Nature is thus more than a diverse gene-bank harboring undiscovered herbal cures for future diseases — although it is certainly this. Nature is also a memory-bank, an idea factory. Vital, postmodern paradigms are hidden in every jungle ant hill. The billion-footed beast of living bugs and weeds — and the aboriginal human cultures which have extracted meaning from this life is worth preserving, if for no other reason, than for the metaphors it still has not revealed. Destroying a rainforest destroys not only a reservoir of genes, but also a bank of future metaphors, insight and models for a modern industrial world.