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Design for a self-regenerating organization

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Abstract

Ashby's 1952 work *Design for a Brain* comprises a formal description of the necessary and sufficient conditions for a system to act 'like a brain,' that is, to learn in order to remain viable in a changing environment, and to 'get what it wants'. Remarkably, Ashby gives a complete, formal specification of such a system without any dependency on how the system is implemented. Here the authors argue how Ashby's formalisms can be applied to human organizations. In business terms, this provides the ability to initiate specific investments and to track convergence on desired business outcomes. No other methodology for organizational change known to the authors has the formal logic or prescriptive power as this application of Ashby's work. Through such interpretations—as rigorous as the application of *Design for a Brain* to mechanical systems—Ashby's formalism enables the derivation of the necessary and sufficient conditions for a corporation to remain viable in a changing market. The authors claim that the only means for an organization to change from the inside and by design is through the creation and protection of processes that recognize the limits of present language and engender the continual introduction of new ones.

Keywords: Organizational design; Organizational change; Learning organizations; W. Ross Ashby; Social systems; Requisite variety; Innovation

1. Preamble

All organizations seek to successfully carry out transactions that achieve their goals and assert their identity, whether to educate college students for employment, to govern a territory fairly, or to make money for shareholders. An organization's transactions are predicated on agreements, and agreements in turn are based on conversations in a shared language. Thus human organizations are delimited by their operation in the domain of language. In biological systems, Ashby's 'essential variables' are measures of the system's operation that are interdependent and that must be kept within strict limits in order for the system to survive, period (think: body temperature, blood pressure, glucose level, respiration, etc.). In social organizations, 'essential variables' are the 'shared truths' of an organization—perturbed by the environment, regulated by employees' actions, and carried in its language. We argue the validity of 'social essential variables' as extensions to Ashby into the social realm.

Furthermore, corporations create 'comparators' in the form of people and processes that interpret market fluctuations against monetary and strategic goals (whether qualitative or quantitative). These goals are perforce expressed in linguistic distinctions held as internally relevant. Thanks to Ashby we can describe the limits of what is not possible under current constraints of an organization's language,

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and therefore focus on changes that are required to operate beyond current limits. Put another way, we want to describe how to extend the capacity of the organization to enable it to survive under conditions that would, in its prior configuration, kill it. The authors apply Ashby's framework to generate new desired states and to detail prescriptive action for change, enabling an organization 'to make the impossible obvious.'

The vast literature of 'organizational design' and 'learning organizations' is usually descriptive instead of prescriptive. Some implications of the role of language are not palatable to most modern organizational experts and their executive clients because it is in their self-interest to lionize the importance of individuals as the means to achieve success (as evidenced by talk of the 'cult of the CEO' and the emergence of 'leadership awards'). A cybernetic approach to organizational design instead emphasizes the requirements for the social system as a whole to support sub-systems that recognize and reward different types of creativity in the three phases of change: invention, discovery, and efficiency-making (see Section 5).

We want to bring a pragmatic view of our direct experience in working inside of large organizations from which our questions arise (Geoghegan at Du Pont from the 1960s through 1990s; Pangaro at Sun Microsystems from 2001 to 2004). We present our argument, in a sense, in the form of a legal brief, where we seek response and criticism. Our argument is part of a broader context in which we ask:

- What is the nature of a good investment?
- How can the social system known as the corporation come to make good investments?
- How can organizations *survive?*

To handle the problem of recognizing and selecting a good investment, we turn to the language of thermodynamics. Investments can be viewed as creating order out of disorder, which is the definition of work. A good investment is one that can create a surplus; and that surplus can be reinvested in the same business space to produce a greater surplus. In other words, the process is generative.

For a given social system such as a corporation, there are ways to recognize and select appropriate investments, but we will not address that aspect here. We will focus on the 'conditions of possibility' that must exist in the social system such that appropriate investment can be recognized, selected, and amplified.

Our work (Dubberly, Esmonde, Geoghegan, and Pangaro 2002) has sought to explain what we have all seen: that upon reaching a stage of maturity, a corporation can no longer successfully reinvest in its current activities and market space. Its prevailing strategy can no longer be the basis for creating new jobs, let alone maintaining the current work force. It is forced to shed social assets—its people—in order to remain financially viable. This pattern led us to a set of questions, summarized in these two:

1. In specific terms, we ask, What must happen so that a corporation can conserve and expand its social capital?

2. More broadly we ask, How can an organization regenerate itself?

This paper addresses the social aspects of these questions. In the process we must show how social systems can learn and successfully adapt to an evolving environment.

We will outline the basic ideas and explanations, reveal their interconnectedness, and lay bare what *cannot* happen—so that the conditions of possibility for regenerative change become obvious in contrast. To fully explore these topics would take a semester, so here we present an outline and sketch the central arguments.

Our questions:

- What is it to learn, to accumulate learning, and to adapt?
- What is the role of 'bio-cost' in learning?
- How is *Design for a Brain* isomorphic with *Design for a Social System*?
- What is change, why is it necessary? How does it occur?
- What is the prevailing management theory on change? What are its fundamental errors?
- What is power and truth? Why is it local?
- How can regenerative change occur?
- What processes give rise to regenerative change, and who can bring them about—by design?

2. Ashby and learning

We begin with Ashby, whose work is of fundamental importance in addressing our questions. The usefulness and practicality of his work should become evident during our presentation.

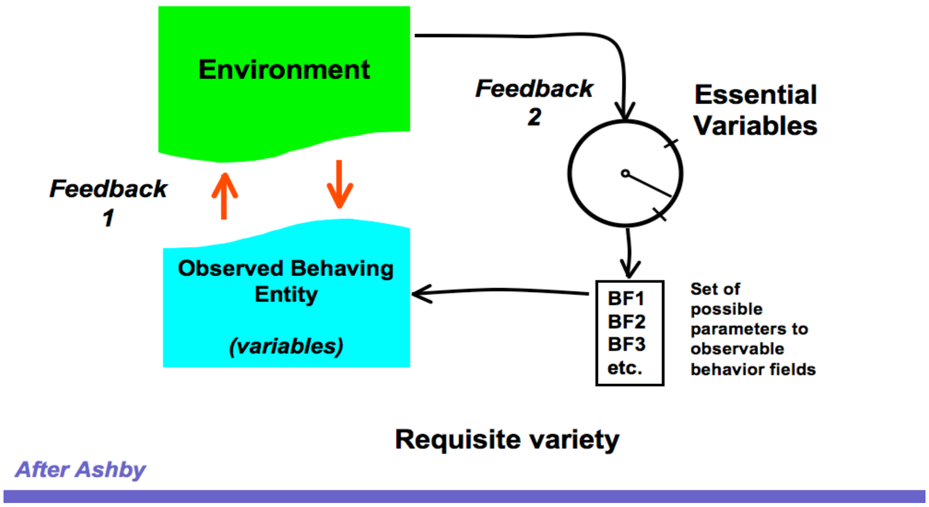
Of paramount importance is the *question* that is asked. The question Ashby posed for himself was, What are the minimum conditions of possibility that must exist such that a system can learn and adapt for the better, that is, to increase its chance of survival? Ashby concludes via rigorous argument that the system must have minimally two feedback loops, or double feedback. The diagram in Figure 1 (next page) is quite recognizable to those familiar with *Design for a Brain* (Ashby 1952).

The first feedback loop, shown on the left side and indicated via up/down arrows, 'plays its part within each reaction/behavior.' As Ashby describes, this loop is about the sensory and motor channels between the system (labeled 'Observed Behaving Entity') and the environment, such as a kitten that adjusts its distance from a fire to maintain warmth but not burn up.

The second feedback loop encompasses both the left and right sides of the diagram, and is indicated via long black arrows. Feedback from the environment is shown coming into an icon for a meter in the form of a round dial, signifying that this feedback is measurable insofar as it impinges on the 'essential variables.'

Essential variables, as used by Ashby, are those 'which are closely linked to survival and which are closely linked dynamically such that marked changes in any one leads sooner or later to marked changes in the others' (Ashby 1952).

Figure 1: Double Feedback



The second feedback loop 'carries information about whether the essential variables are or are not driven outside the normal limits.' The consequence of this feedback is the selection of a parameter from a set of possible parameters in the lower right box, here labeled BF1, BF2… (though usually labeled 'S' in Ashby's diagrams), which result in the observable behavior. That range of parameters available to the system—seen as behaviors—is the variety and, if sufficient for the system to maintain its essential variables, it is the 'requisite variety'—a profound concept and contribution to systems analysis and design that we will come back to later.

This second-order loop '…determines which reaction/behavior shall occur' (Ashby 1952). A change in the parameter causes a change in the behavior (observed) field. This change-in-state-to-change-in-field is a 'step function'—it causes a potentially discontinuous response to the environment—and is of paramount importance to our discussion. (For more on the topic of parameters, see Ashby 1952.)

To evoke the social arena, we call these parameters 'behavior fields', hence our re-labeling to 'BF1', etc., in the diagram. When learning by trial-and-error, a behavior field is selected at random by the system; actions are taken by the system that result in observable behaviors; and the consequences of these actions in the environment are in turn registered by the second feedback loop.

If the system is approaching the danger zone, and the essential variables begin to go outside their acceptable limits, the step function says, 'try something else'—repeatedly, if necessary—until the essential variables are stabilized and equilibrium is reached. This new equilibrium is the learned state, the adapted state, and the system locks-in. The rest of Ashby's formalism is built on this double-loop foundation.

Each step function must be an independent 'memory' to be available as accumulated learning when past conditions re-occur. The step functions also must be distinguished by a gating mechanism such that the system chooses an appropriate step-function from which to obtain the equilibrium-returning behaviors. Otherwise, the system would not know which 'memory in action' to chose upon repeat of environmental conditions, and would in essence 'forget' what it had learned by way of previous actuation of the second-order loop.

The memories are built, area-by-area, as the system develops. Over long periods, as individuals interact with the environment and reproduce (as a species), successful modules can become hard-wired, that is, the learning is embodied in the genes.

There are only two ways to learn: genetic endowment and trial-and-error. It does no good to wait for revelation.

3. Bio-cost

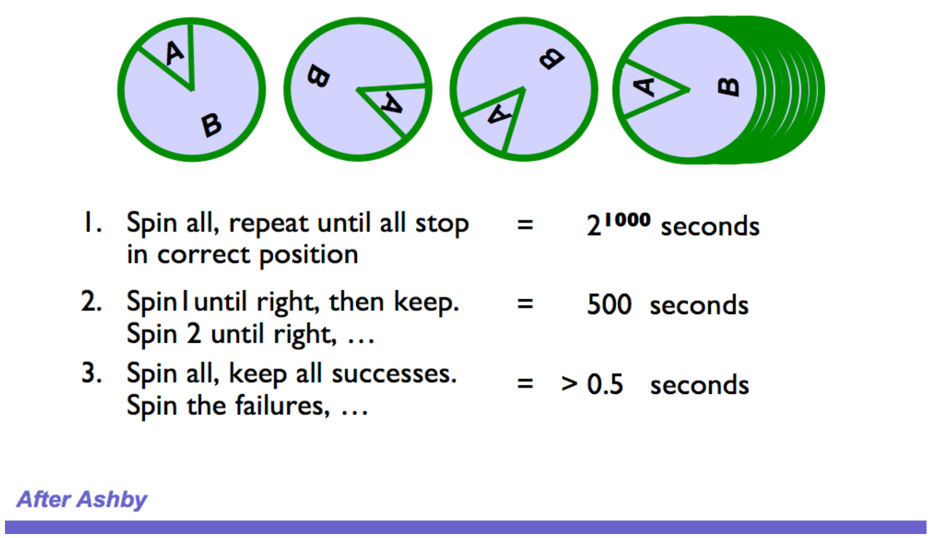
Now we will look at the 'cost' involved in learning. Trial-and-error learning has a 'bio-cost', which is our term for the measurable, biological cost to any system performing an activity in pursuit of 'getting what it wants'. We begin listing the elements of bio-cost as the resources available to the system: time, energy, and attention. In addition, demands on resources lead to an additional component, that of stress, which is a complicating factor wherever a hormonal system is over-laid with—and therefore affecting-and-affected-by—a nervous system (von Foerster 1973). There is much more to say about bio-cost, but this brief sketch suffices our purposes today: Bio-cost is defined as the 'cost' to the living system of its daily processes, with these key components:

- Time
- Attention
- Energy

Resource pressures lead to stress. The consequence of stress is the rejection of complexity.

In the context of bio-cost, let's review the complex task that Ashby proposed in *Design for a Brain* (Ashby1952)—the task of wanting a set of 1,000 spinning wheels to all be stopped in the same position, with the letter 'A' facing up, as in Figure 2.

Figure 2: Bio-cost of complex tasks, e.g., spinning 1,000 wheels.



There are 3 cases to consider:

- Case 1 construes the task as completely parallel in nature, starting by spinning all the wheels at once. Should all the wheels end up in the correct position—whose likelihood is 2 to the power of the number of wheels, or nothing short of astronomical—then the task is accomplished. Waiting for this probability to pay off is clearly futile.

- Case 2 takes the opposite tack, executing the task completely serially, one wheel at a time until the spin is correct. Each sub-system is taken independently of each other, and each is worked on until correct. The time taken is linear with the number of tasks, and tractable.

- Case 3 is a mixed approach, where every subsystem is started, and then failures are re-started until all are correct. Clearly this takes more than 1 spin, but less than Case 2 because many subsystems are working in parallel.

What are the lessons from this simple exemplar of complex tasks? Changing everything at once and hoping that it will all fall into place is futile, as seen in the huge average time taken in Case 1. In our experience, this approach is very common, even though it does not take advantage of intermediate, partial results. A complex task can only be accomplished if broken down into independent subsystems.

We can do that breakdown in a couple of ways. In Case 3, we try everything at once. Many subsystems are in play at the same time and it appears to have low overall bio-cost. But there is a huge disturbance internal to the system with so many subsystems in motion simultaneously. This requires attention distributed across too many different contexts, with high demands for communication across subsystems, leading to confusion and potentially paralysis and death. In Ashby's terms, the demand on the 'channel capacity' is too high.

Complex environments must be approached part-by-part, with little or no communication between the parts until assembly, when each subsystem comes together and is integrated into the whole. This is Case 2. Each subsystem can learn on its own, sequentially, and then all the subsystems can be integrated into a whole. The total degree of change at any one time is not large, and so the bio-cost of change at any one time is low and not destructive, even though the total bio-cost of change, summed over time, is large when the system is complex.

We see from this example that learning to accomplish complex tasks involves high bio-cost. Environmental disturbance, resulting in disturbances to the essential variables, is also costly. To limit disturbances, every system 'simplifies complexity.' The entire construct of the 'scientific laboratory' provides buffers—we don't see and we don't hear a huge range of complexity in order to deal with simplifications so that we can learn about the world in parts, sequentially (otherwise we can't do science). Because of our fragile biology, we build 'stabilizers' that enable us to more easily maintain the essential variables of biological life, such as houses with roofs and insulation and heating systems. In daily life, *habits* are simplifications that shield us from too much complexity, only one of countless examples of cognitive responses to the high bio-cost of living.

Let us summarize, but here we want to bring the context of the social system strongly to mind as we transition to the next section, where we will argue that everything we've said—everything Ashby says—is applicable to social systems.

Systems avoid or dismiss complexity because it is too costly to engage with, and it might even kill you. To survive as the environment changes, systems must learn but learning is also costly. A given system has limits as to the environment to which it can adapt. It may not have the requisite variety or the capacity to learn fast enough. As observers, we note the significant, natural resistance of social organizations to learning to adapt to a complex environment—the bio-cost is high, and the benefits are almost certainly unclear to the beneficiaries. It is possible to amplify learning—a child can be taught new words, or can be given a dictionary and 'exceed the system's requisite variety' (Ashby 1952). Social organizations can successfully expand their variety if:

- they learn part-by-part, serially
- maintain clarity in the local subsystem they are engaged in while learning; and
- avoid over communication between sub-systems.

4. Social systems

We hope that it becomes intuitively obvious that *Design for a Brain* is isomorphic to *Design of a Social System*. Every living system—a living entity in relationship to its environment—evolves in the same way: the previously successful system or social organization that fails to learn and adapt is eliminated. It is not a matter of 'survival of the fittest', but 'survival of the fit', or, more correctly, 'elimination of the unfit.' For humans—*Homo sapiens sapiens*, as Maturana would distinguish us—the ways we formulate our world, behave, and manipulate the environment *in language* are all subject to the law of natural selection. This includes corporations as a dominant class of modern social organization with enormous impact on the global economy and environment, and, inevitably, our everyday lives.

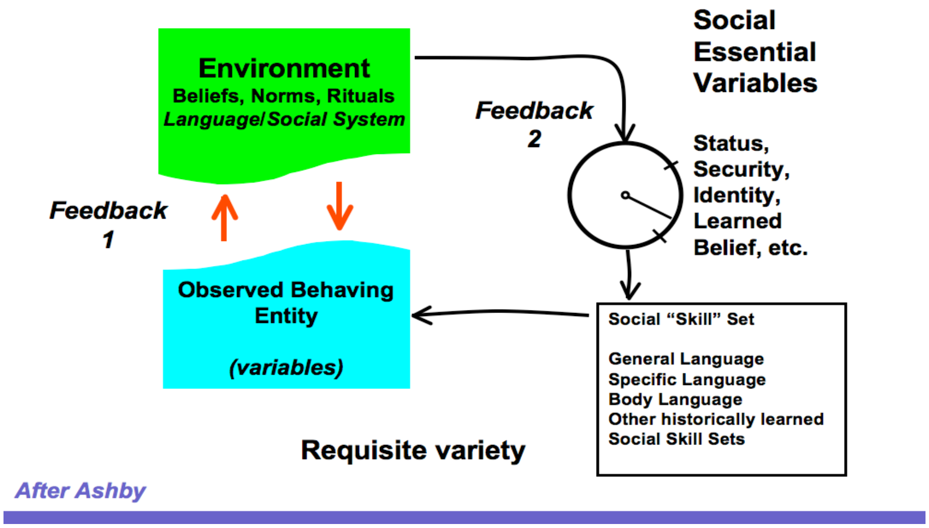
In a social system such as a corporation, the relevant environment is the historically-evolved and agreed-upon system of values, beliefs, social structures, norms, and rituals in its language. This is the relevant environment because *that which is conserved* is what the organization is. It is clear that the medium of behavior in social systems, including corporations, is language rather than the physical world, because language is the medium of the agreements and transactions that constitute the forward motion of a corporation in its own terms (the natural sequence of *discuss, agree, invest*). When measured by its executives or its stockholders in terms of offices and buildings or in any physical space whatsoever, these so-called material assets of the corporation have meaning only in discourse.

As Ashby says, the way for systems to achieve viability is to reach equilibrium with the environment. In social systems, the route to equilibrium for the individual is the process of gaining agreement. An error can only be recognized as such within the context and constraints of the local language. For example, you are not guilty until the judge and jury *say* you are guilty.

What does 'survival' mean for the individual in the social context of the corporation? Further, what constitutes success? Promotion and salary increases are the foundation of recognition, presumably as a sign of contribution to the economic health of the organization (although they *need not* actually reflect that). Increased influence can be a factor for some individuals, in some circumstances. What constitutes failure? Loss of influence, demotion, losing the job entirely by being fired. In sum, for the individual in that social system, the *social essential variables* are those that pertain to social status, identity, the manner of making a living, and, in general, personal social security—that is, 'being OK' as *Homo sapiens sapiens*.

Figure 3 re-casts Figure 1 from the perspective of a social organization, inviting scrutiny from the perspective of cybernetic terminology and models.

Figure 3: Social system (historical).



'Detection and correction of errors', to invoke the common first-order cybernetic phrase, is, as usual, the prerequisite to achieving equilibrium. But in the current language of the individual, what can be detected? Errors can be of two types: first-order errors, where adjustments must be made *within* the current discourse to maintain the (social) essential variables—the kitten adjusting its distance from the fire, or the company adjusting some interaction with customers and partners to improve inventory control. The current language is capable of expressing these errors, and changes to behavior can be made with positive effect.

But what of the second-order errors, where a step-change, a different *class* of behaviors, is required to survive, and the current language is *not capable* of expressing the error? When new errors fall outside the local limitations of language, the social system is at risk. The corporation is doing the wrong things, its version of the truth is faulty, and the individuals inside the corporation 'don't know that they don't know' (von Foerster 1973).

For an example where the first-order language cannot express second-order constructs, consider the following characterization of a major shift in the nature of productivity and economic potential that has been widely expressed as 'the networked economy'—although our characterization of the nature of the new era may be unique, as in Figure 4 (see next page), whose essence is:

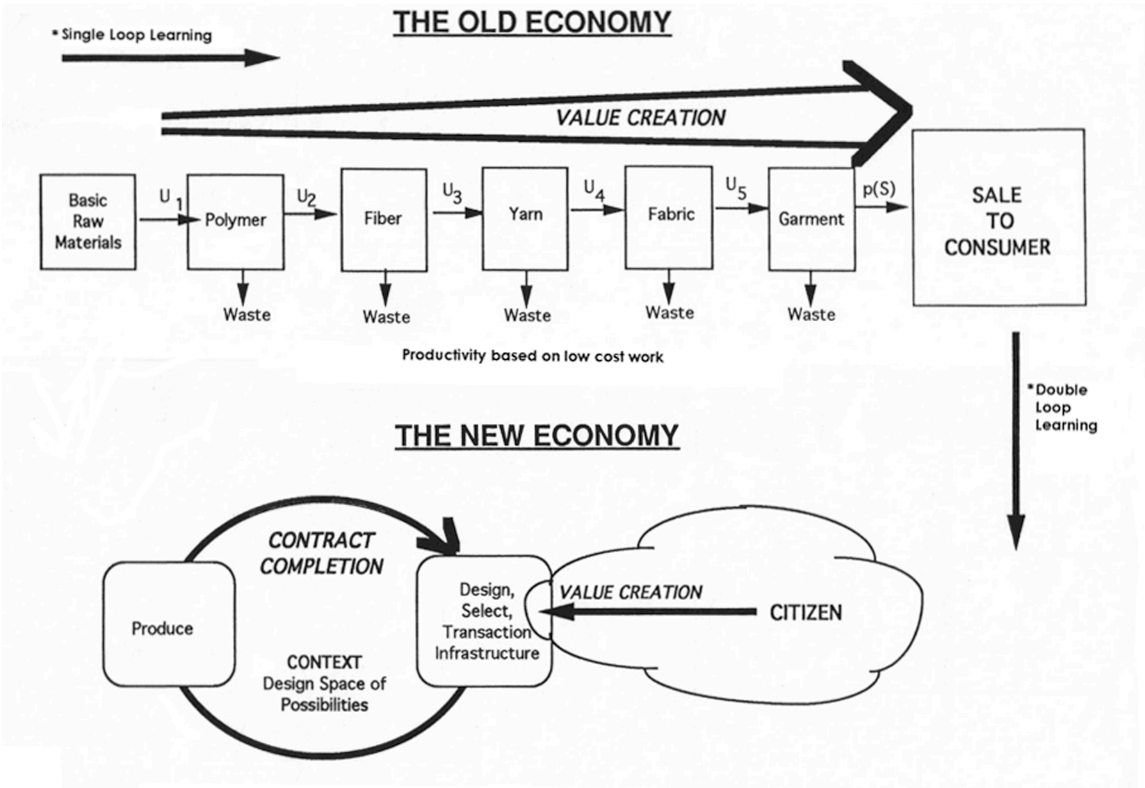
- The mode of productivity of the 'Old Economy', the Industrial Age (up to 1970), was based on *the reduction in the cost of a unit of work*. This is simply an amplification of the muscles.

  This was discussable, thinkable, and all the cogent actions of the corporation reflected this truth: the business plan, investments, and market strategies. However, there has been a major shift, noticed but not yet explained by Alan Greenspan and other economists, because:

- The mode of productivity in the 'New Economy' is based on *the reduction in the cost of reducing uncertainty*. This is simply an amplification of the nervous system.

Figure 4: Upper part: In the Old Economy, productivity is based on low cost of work.

*Lower part: In the New Economy, productivity or creation of wealth is now based on replacing uncertainty (U1 to U5), handled in the Old Economy by mass/energy, by information, hence reversing the industrial process. *Single loop and Double loop learning as per (Schön & Argyris 1995).*



The existence of the confusion over the relationship of productivity and employment in recent times—if productivity is going up, why isn't employment?—can be explained by saying that a new explanation is not discussable in the old language, and so cannot be appropriately reflected in the business plan, investments, and market strategies of most corporations.

We will return to a real-world example of this shift, after a view of the nature of change.

5. Change

Change, the need for change, is visceral. I, or we, are not getting what we want. While more near-in variations can be expressed, the fundamental is, 'I don't feel okay about my future security.' For our purposes, we distinguish three embodied classes of change:

- Class 1: The Act of Invention
    - Opening a new semantic space
- Class 2: Acts of Discovery
    - Focusing on a specific problem

    - Creating new distinctions, new instructions—that is, *language*

- Class 3: Acts to Increase Efficiency
    - Focusing on processes and procedures, e.g., "six sigma"
    - Organizing people, machines, and communications to achieve lower cost per unit of output.

Each of three classes can be construed as the domain of an individual or a group, that is, each class is carried out by a *different type of individual*. This is because the belief system, the values, self-interest, and overt behavior of these three classes are quite different. For example, individuals focused on changes for efficiency *have no 'space'* to consider the issues of invention. It is outside their style and focus, no less outside their language. Lifestyles, 'life meaning', the way in which they achieve satisfaction differs markedly. Once again, the genetic history is one form of learning that has impact on the tendency and capacity for inhabiting a particular class of change; and interaction with the environment (the ontogenesis) does the rest. It seems likely that Einstein, for example, was pre-disposed to Class 1. He would say that himself.

Notice that the flow goes from Class 1 to Class 2 to Class 3. As in evolution and developmental biology, entropy-change goes one way. You cannot go, in same semantic space, from efficiency to discovery, much less to invention. You cannot learn what you already know; you cannot invent what has already been invented. You cannot improve the productivity now by what you have done in the past, because of what has changed in the meantime.

Here is an example of this flow of change from Class 1 to 2 to 3. In the 1960s, Carver Mead asked a key question: What are the theoretical limits of Very Large Scale Integration (VLSI)—that is, how many computational elements can you get onto a given area of silicon? Today we would ask the question as, How many digital switches can be packed into a single chip? Mead thereby initiated change in the form of Class 1, the opening of a new semantic space, a.k.a. *invention*. Beforehand, digital switches were implemented from individual components, assembled onto a separate substrate called a circuit board, and then connected together to form electronic circuits. Mead explored how VLSI—at that point only an idea—would use the single medium of silicon to take on the functions of the individual components *and* the board *and* the connections. The focused parts of the previously separate languages of electronics (circuit design) and physics (manipulation of silicon) were merged to develop a new language. To compute a theoretical limit, new questions had to be posed in that language: How can silicon be made to perform the range of functions of individual electronic components to create a digital switch? What is required to store a digital unit of data? How narrow can an etched line in silicon be, yet still carry reliable signals? How much heat would be produced for a given circuit density, and could it be dissipated without the silicon burning up? Answering these questions *in theory* led to Mead's calculation. Answering these questions *in practice* involved Class 2 of change, the *discovery* of techniques and extensions to the new language.

The difference in size, effort of assembly, and power requirements between circuitry of the day and the vision of VLSI was huge, and it presented a new vision of economic potential. As a result, of course, there would be concomitant interest in tapping into that potential, from investors and inventors alike. This propelled practical progress toward the theoretical limit proposed by Mead. Since answering the questions in Class 2 provided a roadmap for creating new, viable, innovative products with 'huge economic upside', this process fueled the explosive growth of Silicon Valley.

Finally, answering questions in Class 3 of change—how do we do the same thing but smaller, cheaper, faster?—led to the progress acknowledged by Moore's Law, which characterizes the pace at which the industry closes the gap between a current limit and Mead's theoretical limit. Moore stated this in terms of the number of transistors (a primary component of digital circuitry) that can be placed on a given area of silicon, which he estimated would continue to double every two years. In our categories of change we call this *efficiency-making* because economies of scale are exploited and inefficiencies (ignorance) are squeezed out of the *existing* system until none are left. If that point is reached, a new discovery—or, much less likely but much more powerfully, a new invention—is required to bring change.

(By the way, Mead's calculation was way off: his estimate of the theoretical limit was much lower than devices we now use every day. But a new semantic space had been opened, and the potential that it defined was unleashed. Once a new, economically viable space is opened, change is inevitable.)

Another example of these three classes of change starts in the early part of the twentieth century with the creation of means for detecting macromolecules with chemical techniques. This opened up a conceptual space in which it was possible to conceive of natural materials being mimicked by synthetic materials composed out of combinations of long-chain molecules, thereby copying naturally occurring substances but hopefully also improving them—making them more comfortable, durable, malleable, etc. The *invention* of macromolecular chemistry constitutes the opening of a new semantic space that led in turn to, say, thousands of questions as to how to actually manipulate the materials predictably, requiring in turn the *discovery* of many thousands of answers. This gave rise to the creation of nylon, polyester, lycra, etc. Over time, *improving the efficiency* of manufacturing and product-creation processes meant that an existing business could continue to generate wealth for many years—so long as there was ignorance in the system whose removal constituted lower costs and therefore potential profit.

Of course the biologist will recognize that evolutionary and developmental biology comprise components that are isomorphic to the three classes of change, from *invention* to *discovery* to *increased efficiency*.

When we talk about regenerative change, remember that we are talking about a change in the mode of productivity, where actions or 'programs' will lead to a surplus. This surplus can be invested in the same space to produce further surplus, otherwise you are relatively less and less productive and will be 'selected out.'

6. Existing management theory

Now, let's look at the social system of management theorists and at their disembodied perspective on change, for example, the perspective of Schön and Argyris.

1. Single-loop learning: detect and correct errors, *as confined by the existing belief system*, in order to dynamically stay essentially the same. For example, `productivity depends on lower-cost work, so we must invest in more *efficient* machines.'

2. Double-loop learning: detect and correct errors in the belief system itself. The process requires the development of a new set of Social Essential Variables, which means a change in the business theory—a change in 'the truth'—and a change in the interpretation of 'productivity now', for example,

to lowering of cost of reducing uncertainty.

Is it any wonder that Schön and Argyris never observed double-loop learning, as they state in (Schön and Argyris 1995). The inherent resistance to change of belief systems, including the huge bio-cost, means that it is nearly impossible for an existing organization to come to a new belief system on its own without the intervention of a specific process that is designed to bring it about without destroying the existing system. The individuals—whether deep in the hierarchy or the execs at the top—are too vulnerable, and their need to be secure and know that they can make a living and survive in the social order of the existing organization is too great to be comfortable in the face of the necessary change. (They may know intuitively that change is needed, but do not have the requisite variety in language to know how to discuss a secure path forward.) We have witnessed this first-hand and our experience is common, because the failure we are describing—unfortunately for the individuals whose livelihood is yoked to the failing organization—is equally common.

We can apply this reasoning to management theorists in turn. Though Schön and Argyris referenced Ashby, could they, with their background and focus, have seen the deep implications of Ashby's work? Why did they not follow the reasoning from Ashby into social systems, as we have? Our hypothesis is that, because they were not structurally coupled to a business, it was impossible for these professors, as smart as they were, to see what can only be seen by direct experience of the social system of the corporation. To be a bit harsh about it, talking about double-loop learning is a comfortable way to make a living, but double-loop learning does not happen in the field of action. Our personal experience in large corporations, witnessing the ossification of language and paralysis of the organization, has informed our path. Ashby provided a huge leap in understanding in the form of a new language, a new analysis, with which to explain our experience.

Coming to a new understanding is hard. Consider the bio-cost to a single individual to learn a new language, change an entire belief system, change what is considered the truth, change in the manner of making a living—all factors which are conserved (Maturana and Varela 1992).

Now think of such a change at the social level, which is on the order of a 2^n-type problem because the system is relational—each subsystem has to interact with all others (think: team-to-team) and each subsystem has internal relations (think: employee-to-employee) of the same order. Consider these circumstances and reflect on the total bio-cost—time, energy, attention, stress—to change what is in place, while staying alive.

7. The nature of organizations

Schön and Argyris ask, what is an organization?

> 'A government or polis, an agency, a task system, a theory of action, a cognitive enterprise undertaken by individual members, a cognitive artifact made up of individual images and public maps.' (Schön and Argyris 1995)

Their characterization does not include self-interest or history. It is a-biological. Because the systems under scrutiny here, those of humans and organizations and language, are *fundamentally biological*, Schön and Argyris' conclusions, given in the same limited language as their question, can only be flawed. Such an approach to diagnosing and improving organizations is doomed to fail, as we noted earlier in characterizing some classes of errors as *by their nature* being outside the current language. It is as if a solution is sought in Euclidean space, while the solution lies in a different space entirely, that of Riemannian geometry, which creates a new understanding of space-time curvature that is not thinkable in Euclidean space. To solve the problem that Einstein solved means moving outside the limits of current thinking, namely, to realize that time can be construed as local.

In contrast, and in a significant shift of viewpoint from management science, we look at an organization as a set of agreements brought about in the locally limited language, in the self-interest of the agree-ors. But further constructs would be needed to explain the force of resistance that is so evident when change is attempted.

8. Truth and power

That which can be discussed—the nature of what is considered true—as well as what is considered an error cannot be separated from power. Power is a subject that most management schools omit. What, indeed, would the MBA-graduate-now-C.E.O. say if such an inquiry made him feel very uncomfortable? There is a mutual self-interest factor at play here.

Power is typically viewed as constraining, oppressive, dealing with the sovereign; it's about wealth, economics, war, and military might. These are not very useful as an explanatory principle.

To understand power in a useful set of explanations, we have turned to the work of Foucault. We ask readers to resist any generalizations as a consequence of our invoking his work. We need to borrow a few useful concepts and show how it applies to our domain:

- Truth/Power
  - The formation of self-interest 'in the now' is governed by the local truth—'this episteme'.
  - Carries its own set of rules of discourse—truth is not invariant, it is local.
- Reason
  - The accepted language of efficiency, of today.
  - Delimits what, within reasonableness, is an error to be corrected.
- Unreason—what today's reason does not accept
  - Being possessed by the limitations of the current reason.
  - Creating the language of invention, the new truth.

Foucault says,

> 'The history which bears and determines us has the form of a war rather than that of language; relations of power, not relations of meaning. History has no meaning, though that is not to say that is absurd or incoherent.'

> 'Each society has its regime of truth, its general politics of truth; that is, the types of discourse which it accepts and makes function as true.' (Foucault et al 1979)

Foucault sees power as that which exists in relation between people, not a thing in itself. Truth and power coexist. The exercise of power is the production of the local truth. Power determines the rules of discourse, the formation of statements that are considered as acceptable—what is thinkable, what is discussable. Power is 'who talks to whom and about what'. Truth/power is the environment of the Social Essential Variables *now*, locally. Power makes possible the production of things, the production of new knowledge—really a new class of knower.

We fight daily for the truth, in the production of the truth.

From Foucault's perspective, power has positive aspects in that not only does it induce pleasure but, by pervading all human interactions, it makes possible a coordinated local action and local clarity, thus reducing anxiety. The legitimacy of power can be seen from this biological basis as fundamental to the rewards of learning.

Consider the context of efficiency, minimizing bio-cost, a low level of learning, the *now-domain of reason*. In that context a major regenerative change, a new truth, is relative *unreason*. It is very threatening, and consequently is dismissed. For example, Einstein's work can be understood in the context of 'codification' of knowledge and resistance to change:

- 1905—Albert Einstein publishes a short paper on Special Relativity. Renowned scientists of the day interpret the work simply as an improvement on the electrodynamics of Maxwell and Lorenz—re-affirming the 'truth' of the day.

- 1910—The scientific community begins to grasp what Albert had wrought: time is not invariant, it is local.

Regenerative change has huge social bio-cost: to create new language and to learn new language.

The desirability of regenerative change is frequently invoked in the political sphere in organizations: 'we must change, we must be a learning organization, the only constant thing is change', etc. In the context of the personal self-interest of the speaker, this all sounds good; but, in practice, talk about change does not make the distinction between old and new language, and does not enter the field of action. One could ask, do the CEO and his like-speaking administration believe that they should be eliminated by natural selection?

In summary up to this point in our frame of social systems, we have outlined the huge bio-cost involved in regenerative change. The social system must change its language, its business model (which is the strategic conversation), and what is locally true. The concept of 'what-we-are-in-the-business-of' must change. We know from experience that learning a new language, a new truth in which to detect and correct error, takes a great deal of time, energy, and attention—a high bio-cost.

But how can the social system get from here to there? Such a change takes years. And how does it survive in the meantime? The conservative force maintains, 'I want to keep my job doing what I know how to do', and it pervades the social system. Ashby says to simplify, take it part-by-part, don't over-communicate or tax the system as a whole. Now add the insights of Foucault: Truth is power and the CEO believes he speaks the truth—so real change just doesn't happen. Except, perhaps, with relevant insights and mechanisms, it *could* happen, by *design*. It is our conviction that it can, and that to do so, would ultimately conserve resources, minimize anxiety and personal stress, and lead to the *creative conservation of capital*.

9. Mechanisms for change

The forces that maintain the status quo in the social system are huge. Here are three possible ways to bring about regenerative change in the face of them.

1. Machiavelli: We kill the current Prince and all those around him that speak the truth as he does. The new Prince brings with him the new truth. This, for example, is what happened at IBM when Lou Gerstner became CEO in the 1990s where he made huge changes at great social cost—the sale of social assets in the form of layoffs for thousands of employees, including those that spoke the old truth.

2. Philosopher Prince: There may exist a 'Prince' who has a dream and owns the truth, and who can move the entire strategic discussion from his existing position. The approach is to allow the old and still to build the new. As unlikely as this sounds, it does happen, as for example famously in the case of Nokia, which began as a totally different company that held discussions about wood, rubber, manufacturing electrical cables, etc. Based on the CEO's ability to change the truth, there evolved discourses about cell phones and social communication, and thereby a new business was conceived. A new truth, a separate, new social system, was created.

3. By Design: We believe that it is possible, based on the understanding outlined in this presentation, working from Ashby through to Foucault and Maturana, that it is possible in principle to bring about regenerative change in an existing organization, including a change in the mode of productivity from mass/energy solutions to information solutions—as we put it earlier, from reduction in the unit-cost of work, to reduction in the unit-cost of reducing uncertainty. We don't know that this has ever been done—and we think we have shown the reasons why it is so unlikely, especially without the insights and prescriptions that arise after years of living in and reflecting on the organizations in question. The normal structure of the corporation excludes a route of internal, transformative change 'by design.' R&D is subject to the existing Prince and is limited by the language of the Prince. The Prince is constrained by his need to portray a bright future right *now*. He lives in the land of efficiencies and urgency of today, where he defines his self-interest and his history and the history of the organization. If the Prince does not know that he does not know, he therefore thinks he knows. For him, nothing outside what he knows (more comprehensively, *nothing outside his non-knowing*) need change. Under these circumstances, fighting the Prince or letting him control the transformation is futile.

So how can a social system change by design? What are the necessary and sufficient conditions such that regeneration is possible?

10. Enter the concept of the Queen

Unlike the Prince, the Queen lives in the land of new semantic spaces. She is well aware of the new spaces for discovery that are being opened. She is aware of their potential and can speak new language. She is the only mechanism an organization has to create new distinctions.

No one can force or predict when Class 1 changes will occur. However, the Queen is able to recognize and select from newly opened spaces derived from Class 1 changes—*inventions*—those spaces that are most relevant to the regenerative process for her social system—the corporation, with its history and resources. For each selection she can formulate specific, relevant, focusing problems and explain their key aspects, such as the economic potential of these new spaces. She knows or can learn how to proceed in order to 'take the ignorance out'—to remove ignorance that lurks in current understanding, to bring order to disorder, and to create new distinctions in language such that the new truth becomes communicable. This constitutes productive action in Class 2 of change—*discovery*—and precedes the logical continuance into the phase of *increasing efficiency* (Class 3).

The Queen has full power over the 'nursery' in which inventions come about. The Queen is not subject to the Prince. They cannot even converse in the Paskian sense (Pask 1976). Perhaps the Prince thinks the Queen 'speaks in tongues.' This assertion may seem extreme but both authors have repeatedly witnessed this in our careers. Executives exhibit a complete lack of interest in re-evaluating current thinking when the stock price can't recover—when a change of thinking and of language (Class 1) may be the only way out. Strategic thinkers are usually marginalized at this point, or even fired (and strategists resist the 'strategy' word in their titles because they sense this vulnerability, often unconsciously). Internal discussions are subverted to obsessing over how to 'execute better' (Class 3) without examining whether better execution would lead to profitability, no less long-term survival. (This is obvious where General Motors strived to make the wrong car cheaper.) But even if an executive wants to 'foster innovation', lacking any model or even basic distinctions among different classes of change causes confusion at many levels. A very common mistake is thinking of the existing organization—with its day-to-day priorities, skillsets, timelines, and type of creativity of its people—as a viable place to 'transform the business'. This is inevitably doomed. The day-to-day business managers will be frustrated by what they see as a diversion of resources to some vague future that they can't understand, while the forward-thinkers will disparage managers' attitude as being stuck in the past. Resistance rises on all sides, with a force far greater than any financial imperative—or hopeful campaign by 'the leadership'—can override.

We propose the role of the Queen as an explicit mechanism, either embodied in an individual or a way of thinking and a process embodied by a group. In any case, *it must be recognized as a valid responsibility that is protected from whim and confusion*. Otherwise, the Queen's ability to nurture change will be eviscerated by those with the most at stake and those whose position usually makes them unable to see the future: the organization's executives. These individuals possess the most power to prevent change. Often the CEO is the first to want to kill the Queen. This makes it difficult for the Queen to exist, as an individual or as a process. We see confirmation of our concept of the Queen in the prevalence of successful 'skunkworks' (where the activity is hidden from the executives) or even 'spin-offs' (where the activity is put beyond executives' reach). Of course, the 'internet boom' has demonstrated that innovation may occur from a burst of creativity in a 'startup company', which is by definition outside the psychological or monetary influence of a current market or organizational 'truth'. But such forces are those of natural selection, while our focus is internal regeneration by design.

Another reason for her rarity is that the Queen has to have very special qualities. She must be able to see the power of new ideas to 'organize the dis-organized', which is dependent on specific domains and current conditions. It is this talent that allows her to select the domains relevant to a particular on-going social system and to select the important focusing problems to work on (see next section). This is akin to the talent of a 'super entrepreneur' whose insights are not limited to a narrow domain and who can see potential where others do not, because others are not aware that certain new ideas have such power.

And just as the role of the Queen must be protected, the Queen must have the resources to protect the creation of new language and to recognize the new offspring that can flourish under the conditions of the organization (internal) and its environment (external). Hence, 'regenerative change by design' is simple biology: conception through the mixing of existing languages to make new language; birth; development. Perhaps Pask has the best formalism to further explore the details of this developmental path, in language, of the social truth in organizations.

11. Defining a 'focusing problem'

The notion of the 'focusing problem' is central to moving the organization, and is a key element of the Queen's role. Here we outline its necessary features and then offer a real-world example, an attempted implementation of a focusing problem, in the next section.

Focusing problems:

- Must be of problem class that replaces transformation of mass and energy with actionable information flows—so that it participates in the new economy.
- Must have economic potential—removing uncertainty in the system/market is worth something.
- Must be consistent with the social system—to connect with who we are (our history) and what we can see ourselves engaging in.
- Must allow definition of and access to the requisite variety of domains of expertise needed to solve problems.
- Must engage an initial set of individuals who want to do it.
- Must serve as an exemplar or teacher for the business as a whole—so that what is learned can be reproduced.

Defining a focusing problem is highly creative work for which there can be no plan and no timeline. Performing this function inside an existing organization—the cornerstone of 'regenerative change by design—is very difficult. The Queen has a great responsibility in a context that, by the dynamics of language that we've been describing, is unable to understand her. She has to be careful not to lose her head.

12. A real-world example

Let us give you an example of *failed* change-by-design. It was this failure that led to the need to understand power and the necessity of the Queen and her independence. Because of this failure, it became possible to clearly delineate the conditions of possibility—the only path to regeneration by design and the conservation of social capital that we know.

Figure 5: Using pantyhose as an example of a consumer-centered, 1-to-1 model, where all subsystems are connected in real-time.

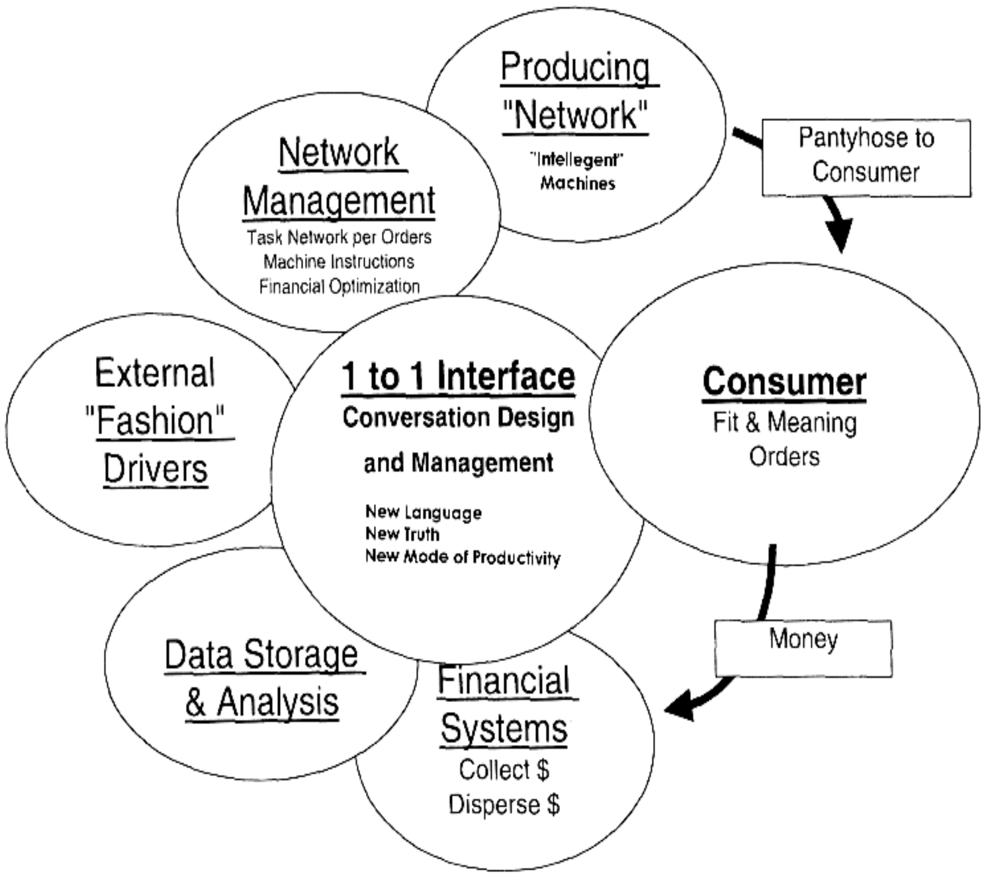


Figure 5 is a model of an actual project in Du Pont. It was developed as an explicit example of a focusing problem, with all the characteristics described in the previous section and brought fully through the phase of *design*. The project proposed the design, sale, manufacture, and delivery of pantyhose to consumers by completely different organizational topology and different signaling mechanisms than those present in current manufacturing methods. One key difference is that a product is specified *in direct conversation* between a consumer and producer, using efficient software interfaces that allow the consumer to express desires and to experience consequences of preferences in terms of price and possibility. Another key difference is that technology, combined with a new social order inside the corporation that changes roles and reward structures, creates conditions such that a product need not be made until it is sold. The result—a product far better suited to a consumer, and no commitment and expense of production until money changes hands—constitutes *reduction in the unit-cost of reducing uncertainty* (which is the basis of the New Economy, see Section 4). This can be explained as follows:

In essence, the new organization conserves mass and energy via a business model that uses abundant capacity to reduce uncertainty in the system—as phrased throughout the paper, 'getting the ignorance out'. This capacity derives primarily from computation and communication technologies that allow direct connection to the consumer; complete product specification delivered via network to the manufacturing machines; and constant feedback about what is working and what isn't at all levels, from the suitability of design options for the consumer, through internal efficiencies, to quality and acceptance of the resulting product. The organization has significantly lower costs because there is no inventory of unsold products and there are no mistakes in making the wrong product, which leads to waste—in physical materials as well as huge bio-cost to the employees—and hence cuts into profits. Note how the human actions and human costs of creating the design are radically changed, because, once engaged with consumers, the organization takes its direction from results and not from hunches. The entire system is feedback-driven starting from the conversation between the consumer and the manufacturing machine, which reduces the number of people involved and shifts the control of product design away from *a priori* commitments—estimates and projections only—by designers and managers and retail buyers. Co-evolution between consumer and producer is enabled, which in turn guarantees success because 'fit' is maintained at the same time that business productivity is high.

The product in this case is pantyhose, chosen for specific reasons of the time, but it could be any product that fits the requirements of focusing problems previously stated. The economic, production, and distribution factors were fully worked out for the project, but we want to focus here on the change in the truth, in the business model, in the social structure. By its nature, the social value in the new model shifts from the traditional vice presidents to the system designer, the engineer of intelligent machines, the network engineer, etc. Jobs from the old model no longer have their status—and they may not even exist. Consider the threat to the manner of living of the 'now' power structure with all its language limitations and urgency.

Optimism for great outcomes was high, because of confidence in the process that designed the project and because overall productivity over current practices was projected to improve by an order of magnitude. Naturally—it's easy to say that now in hindsight—the entire project was dismissed, just at the take-off point. The resistance, conscious or unconscious, was so great as to prevent such a change from happening. (Microsoft is not born inside of IBM.) The details of that dismissal and the overall failure are merely re-statements of what we have said above about the nature of learning and change, bio-cost, language, truth and power. But, have no doubt, someone outside the current social system will do it, hastening the selecting out of the old system.

13. Conclusion

Regenerative change is nearly impossible for the existing social system, because of the high bio-cost of change and the threat to the manner of living of the individuals in it. However, we believe that regenerative change can occur through a known sequence. We claim that it is possible to integrate this sequence into the organization and to make 'change by design' a part of the methods of the modern corporation to innovate and preserve social capital. The focusing problem remains the basis for regenerative change by design, as it is a prescriptive means to the creative conservation of capital.

We summarize our paper with the necessary and sufficient steps for the design of a self-regenerating organizations:

- Conception/Inventing
    - Opening of a new semantic space.
    - New distinctions arise as a consequence of synchronization across perspectives of previous domains (Pask).
    - To come together—"have sex"—produce new languages.

- Birth & Development/Discovery
    - Communication of the invention through ontogenesis.
    - Only possible from a focusing, purposeful problem.
    - Extensions of the new language are required to bring the conception to fruition in the environment—to make a product/service that delivers value.

- Specialization/Efficiency
    - Continual improvement of the product/service.
    - Doing it better, scaling it further.

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Bios

Michael C. Geoghegan was born in Dublin, Ireland, where he got his Ph.D. in chemistry at the University College, Dublin. He then came to the United States as a post-doc at Columbia University in New York where he also received his M.B.A. He had a long career at Du Pont in management and research, and was appointed Research Fellow, allowing him the autonomy to pursue his own agenda. From the freedom of that position, he studied the work of scientists, cyberneticians, and social theorists while funding research on the nature of wealth creation in a networked society. He is currently working on a book that chronicles his life as a scientist at work in the business context and that includes a synthesis of thermodynamics, cybernetics, and evolutionary theory to explain how economic potential can be calculated in advance of investment decisions.

Paul Pangaro was educated at MIT as an undergraduate in computer science and drama, and he earned a Ph.D. with Gordon Pask at Brunel University (UK) in cybernetics. He founded a software consultancy based on applications of Pask's conversation theory to decision-support software, and over a ten-year period moved from contracts with the US Army and UK Admiralty to development of training for nuclear power plant operations. Through engagements with Michael Geoghegan at Du Pont, as well as Lotus Development Corp and Xerox and elsewhere, he became interested in the internal dynamics and technology strategies of large organizations. He worked for ten years in Silicon Valley, where he consulted to and held positions as chief technology officer with internet startups, and where he was senior director and distinguished market strategist at Sun Microsystems. Now based in New York City, he is co-founder of a consultancy that supports the organizational, marketing, and product directions of startups, and that works with innovation teams in organizations such as Citigroup (http://cyberneticlifestyles.com).