Prof Derek Hitchins CEng, PhD, MSc,
FIET, FCMI, Wg. Cdr., RAF Retd.

INCOSE Pioneer

Systems Scientist, Systems Anthropologist

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LifeCycles—a Very Different Way of Systems Thinking…

Serendipity! It was back in 1989—I came across an article in Scientific American, *The Yellowstone Fires,* by two researchers, (Romme & Despain, 1989).

The fires were unusual in that they occurred about every 40 years, in a forested area where ***lightning strikes*** were frequent: the *cause* of forest fires was ever present. So, why fires *only after 40 years? Curiosity aroused!*

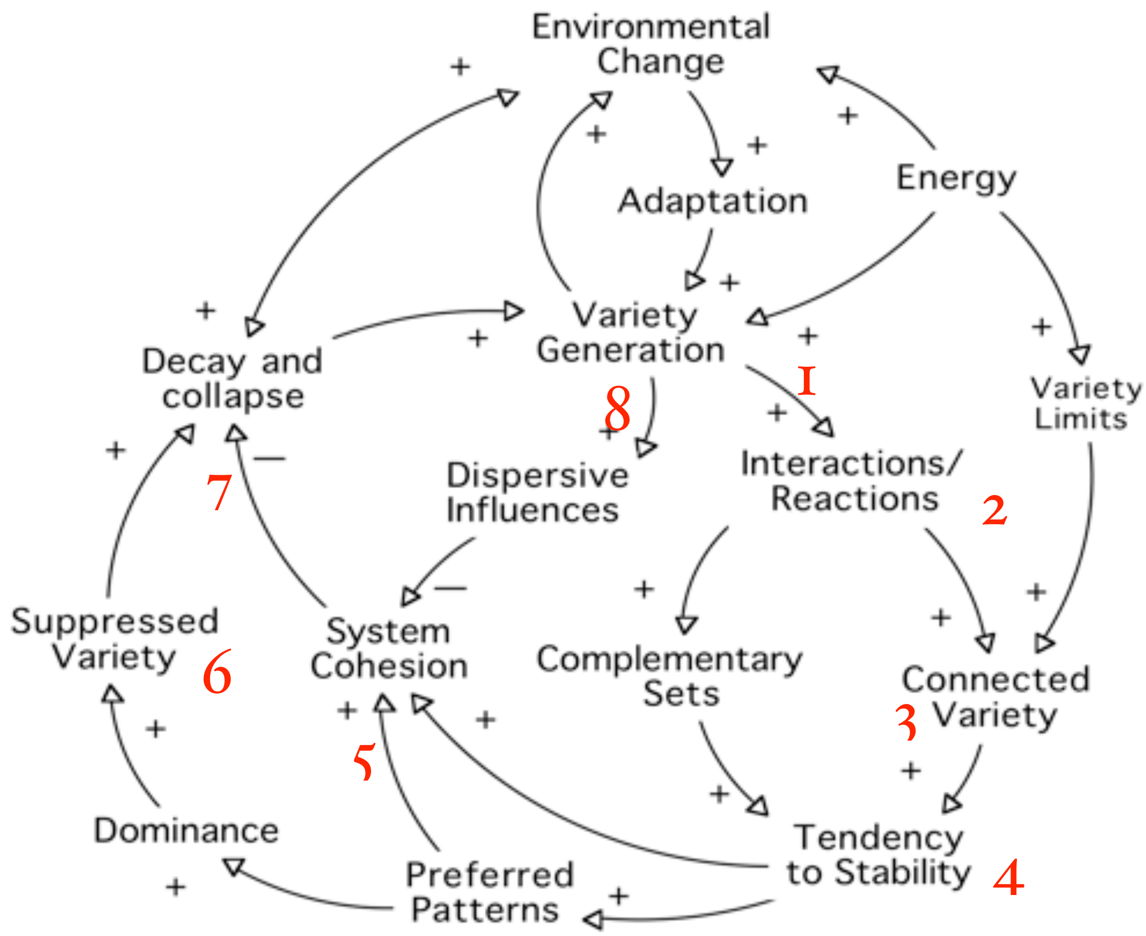
The researchers found that, after each fire, the scorched ground started to come to life with buried, fire-adapted corms sprouting, and with seeds brought into the area by birds and bats. Soon there was vigorous scrub, grasses and bracken, fertilized by the ashes from the previous forest fire.

Tree growth followed. Softwood trees grew fastest, only to die and fall after a few years, and to rot down in the damp undergrowth. That made room for the slower growing hardwoods, which grew tall, their canopies eventually shutting out the rain and sunlight, allowing a dry tinder to form from the rotted vegetation/undergrowth.

This whole process took some forty years, by which time the stage had been set for ***lightning to strike*** the now-dry tinder, *et voilà,* the next forest fire…and the cycle repeated.

I was intrigued. Nice piece of research. Well done. Yet, could it be, perhaps, ***a metaphor for any system's lifecycle—an (eco)system's lifecycle?*** And, since an ecosystem is not

Fig. 1. The Systems Lifecycle Map

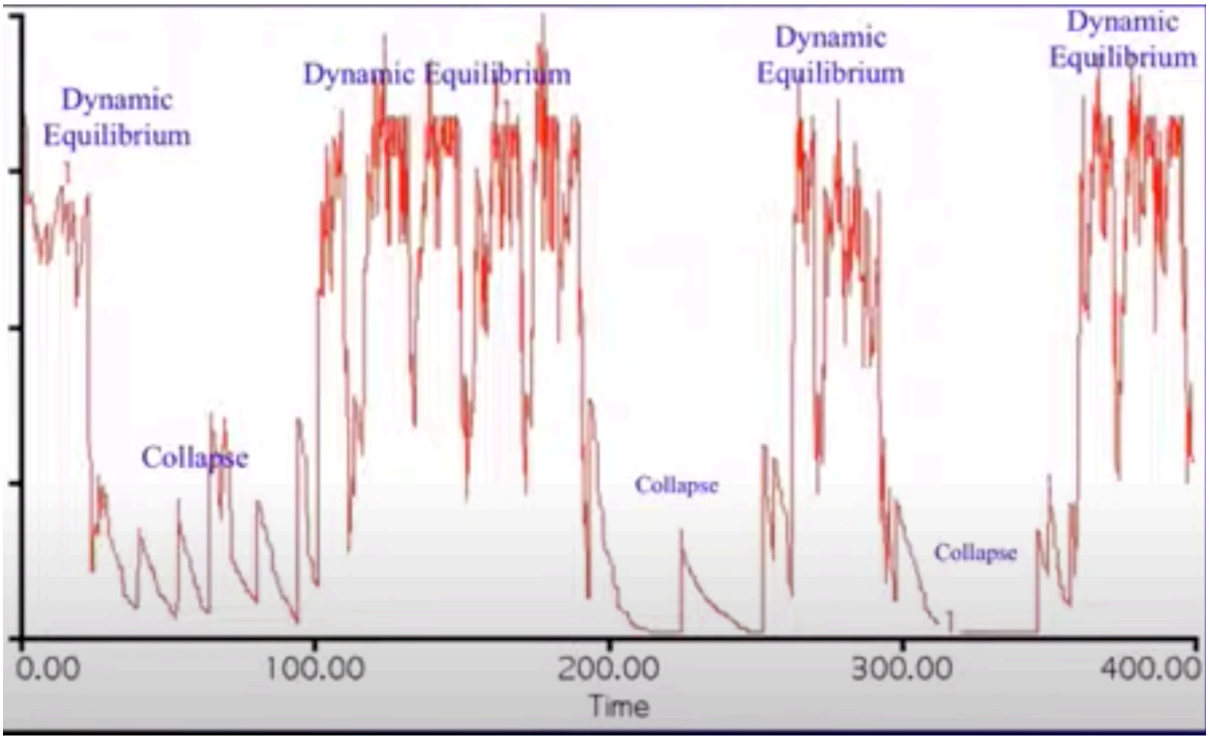


Note the positive feedback loop: Variety generation; Dispersive influences (i.e. Variety that does NOT interact constructively), System Cohesion, Decay and Collapse. May trigger sudden 'domino' collapse of 'Moribund System' when there is an Environmental Change…

only a community of interacting organisms and their physical environment, but also–more generally–*a complex network or interconnected system*… Could this prove *very* interesting?

Eventually… I came up with the *Systems Lifecycle Map,* ostensibly for any complex system/ecosystem—the heart of Unified Systems Theory (UST) of which, more later. The Systems Lifecycle Map is a continuous causal loop model, so–naturally–I explored its *system dynamics* over an extended period, with the following, interesting results:—

Unified Systems Theory (UST)— (Hitchins, 2003)
Figure 2. System Lifecycle Dynamics



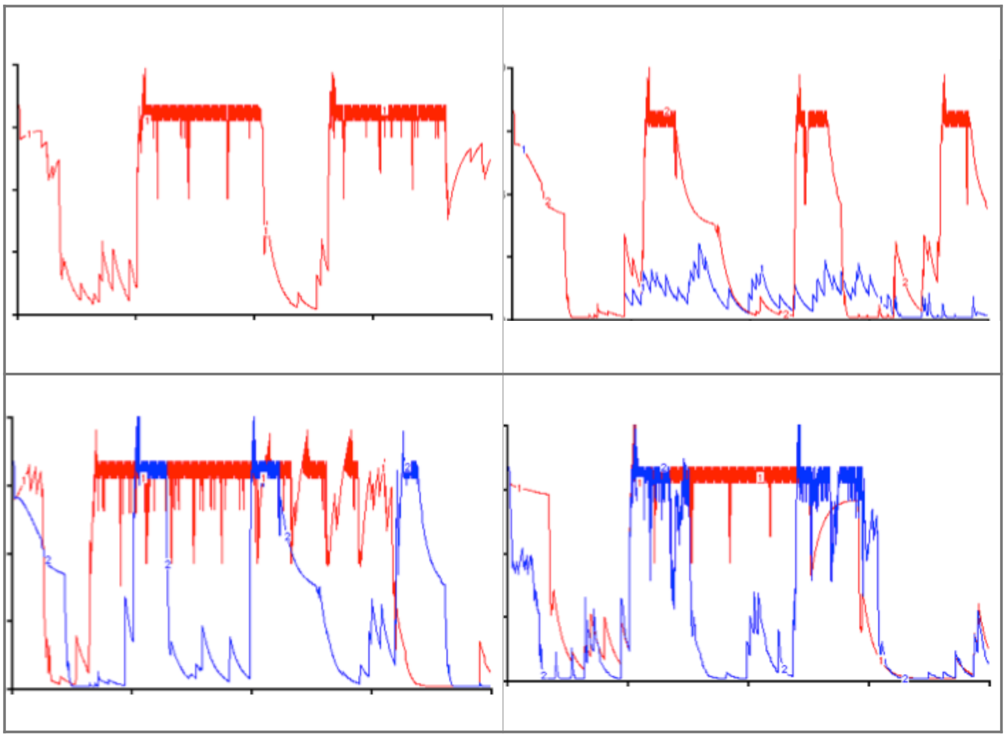
The graph differed every time it was run, but always followed the same general form: periods of dynamic equilibrium (lifecycles), themselves highly dynamic, but within limits; interspersed with periods of collapse, as shown, during which the “system” seemed to be trying to revive…to its “more organized,” yet still highly dynamic state.

But, surely this is how extended, interacting systems ‘behave’? Not necessarily the whole network of systems at one time. So, in an extended *ecosystem,* there may be a fire or disease in one part, while the rest carries on, relatively unaffected. And in an urban/city ecosystem, with many districts, suburbs, arrondissements, etc., similarly, some may become ‘unfashionable,’ ‘impoverished’, crime-ridden, rundown, only to be revitalized later, while the others remain largely unaffected.

On the other hand, some civilizations seem to have behaved *en masse* just like the graph—most notably, ancient Egypt, still today’s longest enduring civilization (3 millennia), with its 3 principal kingdoms. Old Kingdom, or Pyramid Age; Middle Kingdom; and, New Kingdom. Interspersed with brief, so-called *Intermediate Periods of relative chaos…remarkably* like the graph!

Were these three Kingdoms, in effect, three Lifecycles? Even reflecting the turbulence that inevitably occurred <u>within</u> each and every Kingdom?

Fig. 3. Varying System Parameters



a) Upper left: nominal/reference behavior.
b) Upper right: varying variety/diversity; low line 1, moderate line 2 (red).
c) Lower left: varying available energy; low line 2, higher, line 1 (red).
d) Lower right: varying dispersives; moderate dispersives, line 1, high dispersives line 2 (blue).

Experimenting with the parameters: Variety/Diversity; Energy; and, Dispersives in the Systems Lifecycle Map resulted in the characteristic patterns shown above:—

- Decreasing variety/diversity resulted in fewer, short-lived periods of dynamic equilibrium (homeostasis/life-cycle). Decreasing diversity even more prevented reaching homeostasis, i.e., no 'organized' (eco)system ever formed…

- Reducing the available energy entering the (eco)system also resulted in fewer, short-lived periods of homeostasis (lifecycles). Alternatively, *increasing* the energy resulted in a near-continuous homeostasis interspersed with longer periods of collapse, albeit with increasingly complex, highly charged dynamics.

- Finally, with more dispersives generated, the briefer, more separated in time, and more irregular were the periods of homeostasis…The dispersives *(introduced* varieties that did not interact constructively to become *connected* varieties) effectively served as pathogens…

The figures above, with their supporting narratives, indicate the basis for the Unified Systems Theory (UST) (Hitchins, 2003) and seven important UST Systems Principles, as follows:

1 ***The Principle of Reactions (a.k.a. Le Chatelier's Principle)*** addresses the tendency to react to change and towards equilibrium:

If a set of interacting systems is at equilibrium and, either a new system is introduced to the set, or one of the systems or interconnections undergoes change then, in so far as they are able, the other systems will rearrange themselves so as to oppose the change and establish a new point of equilibrium.

2 ***The Principle of Cohesion*** addresses the changing form of an interacting system and limits to growth:

A system's form is maintained by balance, static or dynamic, between cohesive and dispersive influences. The form of an interacting set of systems is similarly maintained.

3 ***The Principle of Adaptation*** addresses the ability of a system to endure in a changing environment:

For continued system cohesion, the mean rate of system adaptation must equal or exceed the mean rate of change of environment

4 ***The Principle of Connected Variety*** addresses the basis of stability between interacting systems:

Interacting systems stability increases with variety/diversity, and with the degree of connectivity of that variety/diversity within the environment

5 ***The Principle of Limited Variety*** addresses the limits to differentiation in interacting systems, and hence the limits to stability

Variety/diversity in interacting systems is limited by the available space (degrees of freedom) and the degree of differentiation

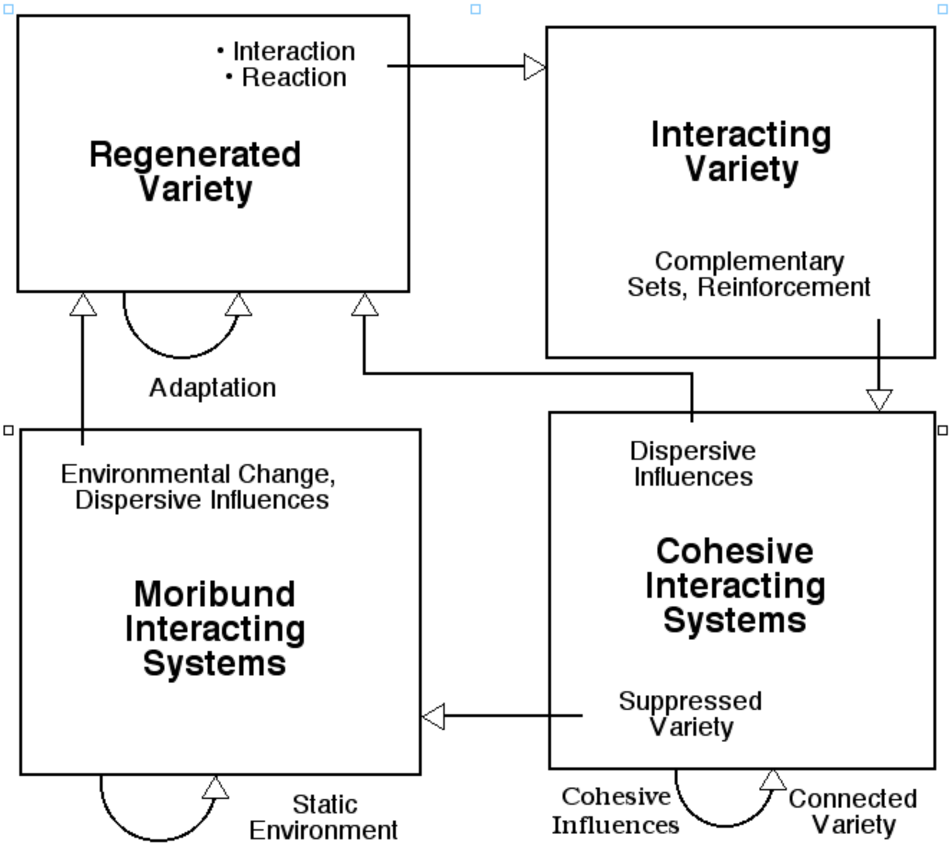
6 ***The Principle of Preferred Patterns*** addresses the emergence of dominance:

The probability that interacting systems will adopt locally stable configurations increases both with the variety of systems and with their connectivity.

7. ***The Principle of Cyclic Progression,*** importantly, examines life cycle:

Interconnected systems driven by an external energy source will tend to a cyclic progression in which system variety is generated, dominance emerges to suppress the variety, the dominant mode decays or collapses, and survivors emerge to regenerate variety. (see Finite State Transition Diagram, opposite)

Fig. 4. Finite State Transition Diagram



There are four states, as shown. With dominance suppressing variety, it is possible for the (eco)system to become moribund. In this state, the system may appear unchanged. However, it lacks the variety necessary to cope with any environmental change. When that change eventually occurs, as it surely must, the whole collapses, often suddenly, and in collapsing it creates variety for the next incarnation. Classic example of such a so-called domino collapse would be that of a number of Chain Stores, the Soviet Union after the Cold War…and conceivably the demise of the dinosaurs, too…

These principles, and particularly the last, provide the basis for conceiving and understanding the value and application of a new Complexity Law—the "Law of Entropic Cycling"

What would such a new (eco)systems Law of Entropic Cycling be about? Like Kelvin's Second Law of Thermodynamics, it will be about everything in general, but about nothing in particular. In fact, it should *complement* the Second Law, which applies exclusively to the increasing entropy of *closed (*isolated) systems. The Systems Law of Entropic Cycling, on the other hand, applies to unbounded *open, interacting* systems.

The following is proposed as a new, Complexity Law…
…Systems Law of Entropic Cycling:

> ***Open, interacting systems' entropy cycles continually at rates and at levels determined by available energy, generating corresponding periods of self-organized dynamic equilibrium, 'lifecycles,' interspersed with periods of disorder, collapse…***

The law applies to many, open, interacting systems, containing many systems, with the ordering mediated by connected variety.

In this, it does not seek to operate within any boundary, unlike the Second Law which, by referring to 'isolated systems,' implies an imaginary boundary across which energy does not pass in either direction.

In contrast, the Law of Entropic Cycling applies to an unbounded network of energized systems, ecosystems, providing a basis for understanding (parts, or whole, of) this extensive network without limits or preconceptions.

The Unified Systems Theory (UST) can help predict the outcome of (eco)system behavior. Consider Global Warming. Warming injects more heat ***energy*** into the atmosphere, which absorbs more moisture. So, we may expect: not only, prolonged heatwaves; but also prolonged and deeper depressions, rainstorms, cold spells, etc. Then, prolonged droughts and prolonged floods. Altogether, more extreme weathers, maintained for longer periods…and, paradoxically for Global Warming, extended periods of cold weather, too…all courtesy of UST.

Wide area information systems, such as air traffic management, national health and defense systems-of-systems, are not exempt from embarrassing, hard-to-explain, 'outages,' or crashes. Could these highly energized (eco)systems be subject to Entropic Cycling, i.e., life-cycling? It's an intriguing idea, but difficult to prove…

UST also helps to cast doubt on some established hypotheses. The *catastrophic end* of the dinosaurs is one such. It is supposed that a meteor that struck the Earth some 64 million years ago, "wiped out" all dinosaurs.

Only…dinosaurs were reptiles, yet other reptiles—*crocodiles, alligators, turtles, etc.*—alongside the dinosaurs—were unaffected. As were *insects, early mammals,* etc. *Indeed, these flourished…which is rather at odds with the much-publicized, "nuclear winter" hypothesis…*

Moreover, the records show that the dinosaurs were beginning to fade out some time *before* the meteor strike, and lasted tens of thousands of years *after* it… UST indicates that there is no need to call upon external intervention by meteor, no *deus ex machina.* Collapse of the dinosaurs may have *been overdue*—the end of their very long lifecycle…c.177MY.

Dinosaurs had become *the overall dominant species,* with a multitude of variations, very large, large & small, carnivore & herbivore, hunter, scavenger & prey, all well adapted to, and occupying, most ecological niches in a long-stable environment. Had their dominance and ubiquity come to suppress the overall biological variety/diversity, creating a moribund ecosystem? If, and when, that environment changed, would they be able to adapt quickly enough to keep up with the change? Or was the stage already set for an inevitable domino-style collapse of the dinosaurs…?

(See Figure 1, *The Systems Lifecycle Map, p2,* and Figure 4, *UST Finite State Transition Diagram, p8.)*

For many dinosaurs, their size and consequent ***longer reproductive cycle*** would have militated against rapid response to environmental change. And that change could, *possibly,* have been accelerated by a meteor strike and the subsequent clouds of dust thrown up to obscure the sunlight, so temporarily affecting ground temperature and the growth of vegetation…But, seemingly *not enough to materially affect other reptiles, insects and vulnerable early mammals…*

Which might further suggest that the meteor strike 64MY ago did not so much "wipe out" the dinosaurs, as *possibly* contribute to a change of environment that was already under way…*and it was that change of environment,* over tens of thousands of years—the blink of an eye in geological terms—that resulted in the demise of the dinosaurs…with, or ***without,*** the meteor strike.

Meanwhile, smaller animals, with sexual reproduction and shorter reproductive cycles, could adapt much more readily, occupying the "energy-space" relinquished by the dinosaurs, generating a profusion of new species, with mammals occupying many of the newly-available ecological niches in a much-changed and changing environment.

UST illustrates how it would be possible to 'dismantle" an (eco)system, or—on the other hand—perpetuate an (eco)system…

To dismantle an (eco)system, it would be necessary only to progressively reduce its connected variety/diversity. A common example of this would be the practice of corporate accountants who, during an economic downturn, dispense with employees and trades considered unnecessary to core survival. Subsequently, when the economy picks up, the company will find itself unable to respond as it then lacks the variety/diversity to take on new business.

A recent instance concerns UK airports, during and after the COVID lockdown, when trades such as security, baggage handling, etc., were deemed superfluous. Come the recovery, the airports found great difficulty in recruiting, and handling returning passenger traffic, while airlines found themselves offering capabilities that, in the event, they no longer possessed.

In a not dissimilar vein, chains of long-established department stores have collapsed unexpectedly in recent years. Unable to keep up with changing culture and fashion, they no longer led the fashions, but offered dated goods and commodities, sometimes in dated premises, which no longer appealed…*(Principle of Adaptation, p.7)*

Alternatively, to maintain an (eco)system indefinitely, it would be necessary to eliminate dispersive elements, and to continually refresh and maintain connected variety to accommodate the inevitably-changing environment. Examples of this are to be found in long-lived organizations that continually 're-invent' themselves, and their product ranges, such as Apple and Microsoft…

Finally, the UST provides us with the tools to examine such phenomena as government policies of inclusivity, diversity, equality, etc., and to not only understand their collective purpose, but also to detect any flaws/anticipate counter-intuitive outcomes…

In this, UST appears to be unique. But I shall leave it to you, dear reader, to ignore or employ the UST as you deem best.

And Good Luck in your endeavors…

References:

Hitchins, D.K., 2003, *Advanced Systems Thinking, Engineering and Management,* (Chapter 6. Systems Lifecycle Theory), Artech House, Boston MA

Romme, W. H. & Despain, D. G. (1989) The Yellowstone Fires, *Scientific American*, **261**, (5).