

Thank Denise and IBE for the opportunity to speak about the ‘Patterns from Nature project.

Brief introduction: I am not an academic – my only academic affiliation is when they track me down to for donations. I spent more years that I care to admit as an Software Architect, involved in conception, design and implementation of large computer systems. As an architect, I saw the value of understanding how systems worked, without forgetting that ‘trees’ really do exist. I also dabbled in how to encourage innovation, before it became the latest corporate bandwagon.

I stumbled on “Biomimicry: Innovation Inspired by Nature” by Janine Benyus and was intrigued not only by the novel approach to innovation, but also by the upbeat message that we can have a rich and vibrant existence while living with ecological limits. I contacted Janine in late 2002 and got involved with both the Biomimicry Guild and Biomimicry Institute on communications strategies and post-secondary education programs. In late 2006 I started a project on how Biomimicry could more effectively transfer knowledge to designers (in the broad sense) who lack biology background.

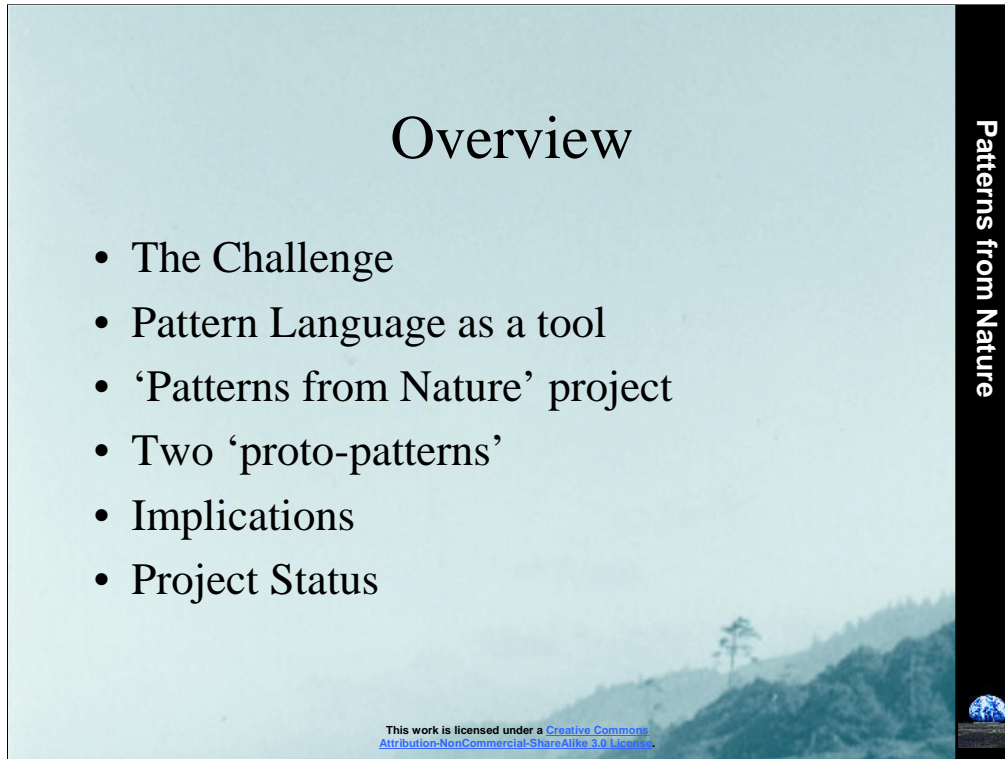
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Pathobiology is defined as an interdisciplinary field devoted to basic research into the mechanisms of disease, and serves as a bridge between basic biomedical research and clinical medicine in that it leads to new scientific knowledge in an environment where it can be translated into direct benefits for patients.



Overview

- The Challenge
- Pattern Language as a tool
- ‘Patterns from Nature’ project
- Two ‘proto-patterns’
- Implications
- Project Status

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Patterns from Nature


Whiz through the presentation, to leave time for questions at the end

The Challenge

- How do we organize knowledge about biological systems?
- How do we communicate that knowledge to other disciplines?
- Need more than a methodology or a collection of facts
- Need to grab people's attention
 - the “six inches between the ears”

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Organized by species, not by function.

•Tendency to focus on exceptional species where the strategy is not well understood.

Written in biological jargon.


Ultimately a form of problem-solving.

•Many ‘generic’ methods, but they assume you have expertise in the field

•Many textbooks and databases, but few help you apply the information

Last, but not least, how do you overcome the natural reluctance to leave your ‘circle of comfort’?

Psychological Inertia (D. Mann)



- * Problem solving is like digging for treasure in a field
- * If a hole already exists, our inclination is to dig it deeper
- * The deeper the hole, the more difficult it is to see what's happening in other parts of the field
- * If someone else comes along, we encourage them to jump in the hole with us
- * The overall effect is called **PSYCHOLOGICAL INERTIA**

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Even if you are somewhat familiar with another discipline, success can be our worst enemy.

It can influence the words and images we use to describe a problem, the solutions that are 'top of mind', the selection of 'tried and true' methods that have always worked in the past.

New concepts need to be communicated in an accessible and compelling manner.


Tell a story that both explains and is relevant/practical.

Pattern Language (Alexander)

- Developed in late 1970s to capture the 'wholeness' and 'aliveness' of good architecture
- Defines a simple yet powerful structure for each pattern
 - Descriptive (insight)
 - Generative ("*Useful, usable, and used!*" - Appleton)
- Defines a process to create and use these patterns

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Related to but NOT the same as visual patterns

• **Recurrent combinations of problem/solutions sets across many systems**

Best analogy is a template, in the sense of a dress pattern

• **Imbeds knowledge and guides execution, but allows for flexibility**

• **Not a mold that creates duplicates**

Insight:

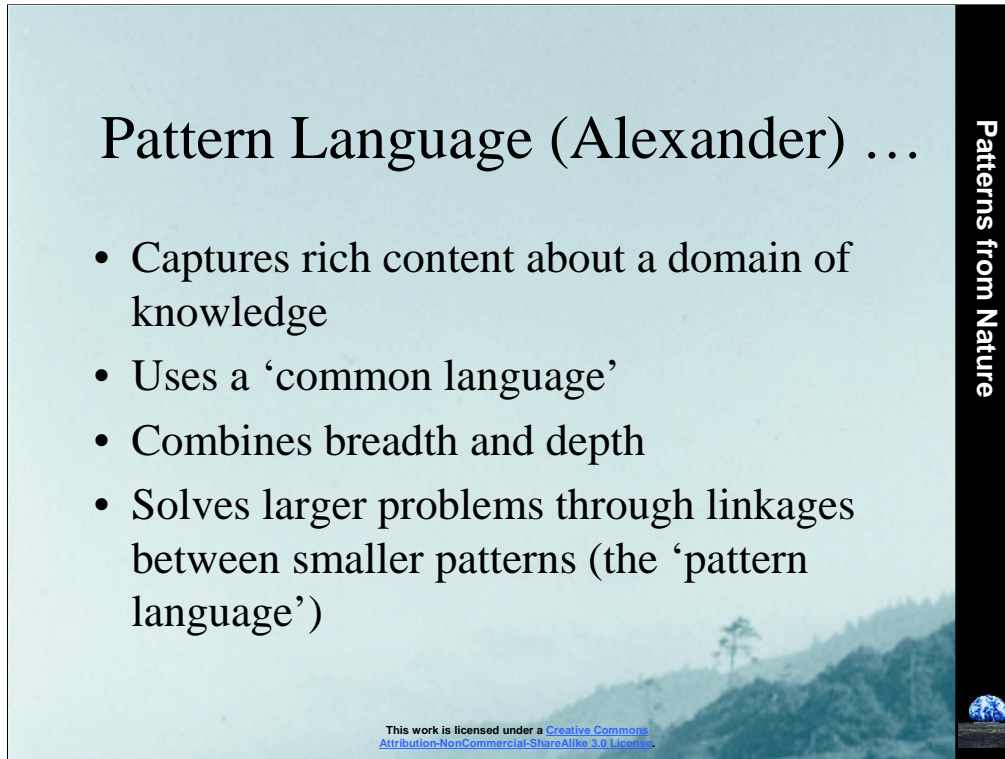
• **in what context will the problem be found,**

• **what drivers/forces cause the problem to occur,**

• **what are the limitations of the solution.**

Emphasis on practical applications

• **specific steps that allows the user to develop a solution adapted to the specific situation.**



Pattern Language (Alexander) ...

- Captures rich content about a domain of knowledge
- Uses a 'common language'
- Combines breadth and depth
- Solves larger problems through linkages between smaller patterns (the 'pattern language')

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Patterns from Nature

Background information, images, case studies and linkages

Provides a communications bridge between disciplines

Comprehensive coverage, in breadth and depth

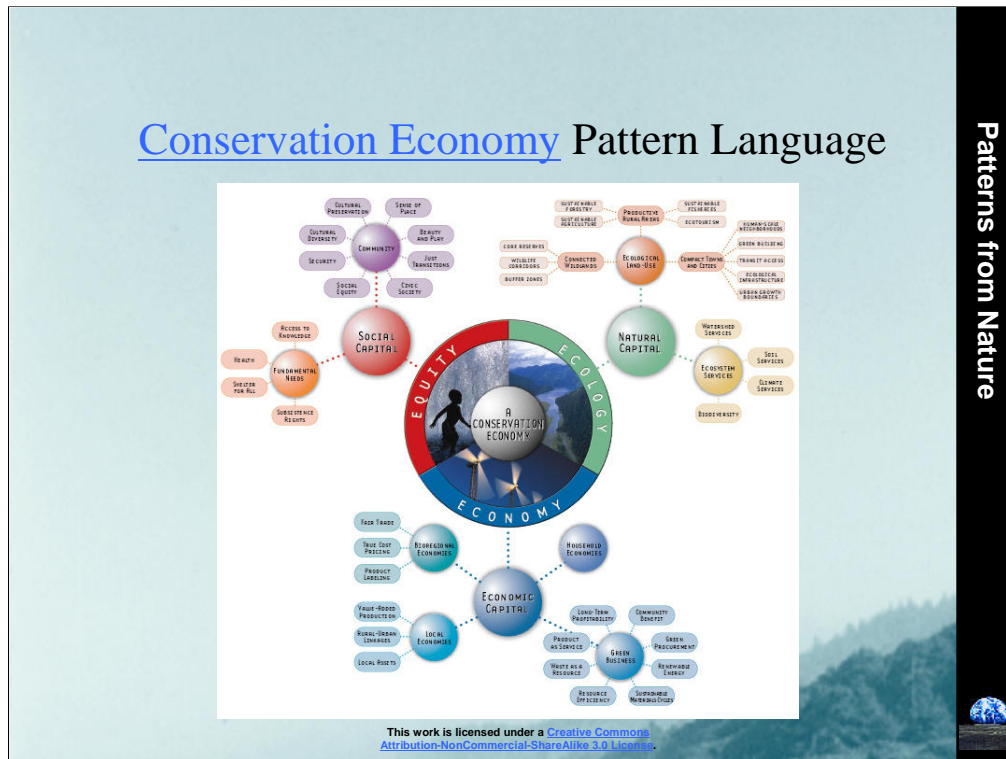
•Documents the system and all of its component parts

Allows designer to see:

•how patterns at level of focus complete those at a higher level (systems perspective)

•In turn, how patterns are completed by those at a lower level

Developing the grammar can be one of the most difficult steps in developing a pattern language

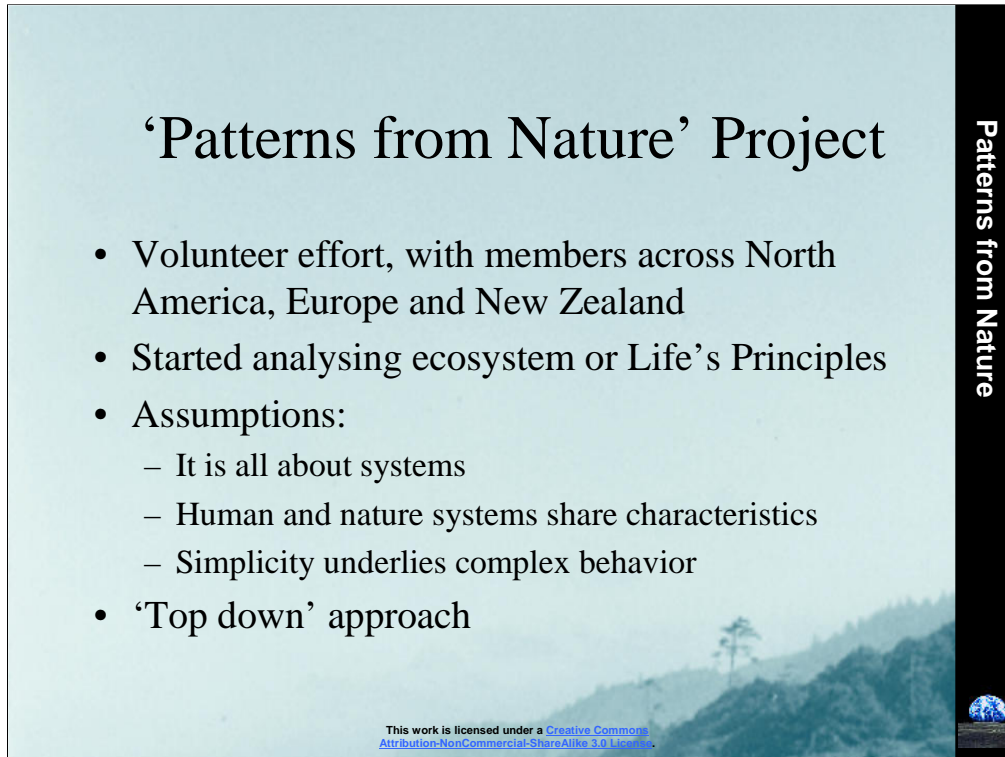


Developed by Ecotrust out of work done in bio-regional planning for the Pacific Northwest.

Each pattern includes extensive background information, images, case studies and linkages to other patterns.

A designer can pick an area and level of interest, then navigate sideways, up and down in the pattern language.

The pattern network is not fixed – designers build their own networks relevant to the problem and context



‘Patterns from Nature’ Project

- Volunteer effort, with members across North America, Europe and New Zealand
- Started analysing ecosystem or Life’s Principles
- Assumptions:
 - It is all about systems
 - Human and nature systems share characteristics
 - Simplicity underlies complex behavior
- ‘Top down’ approach

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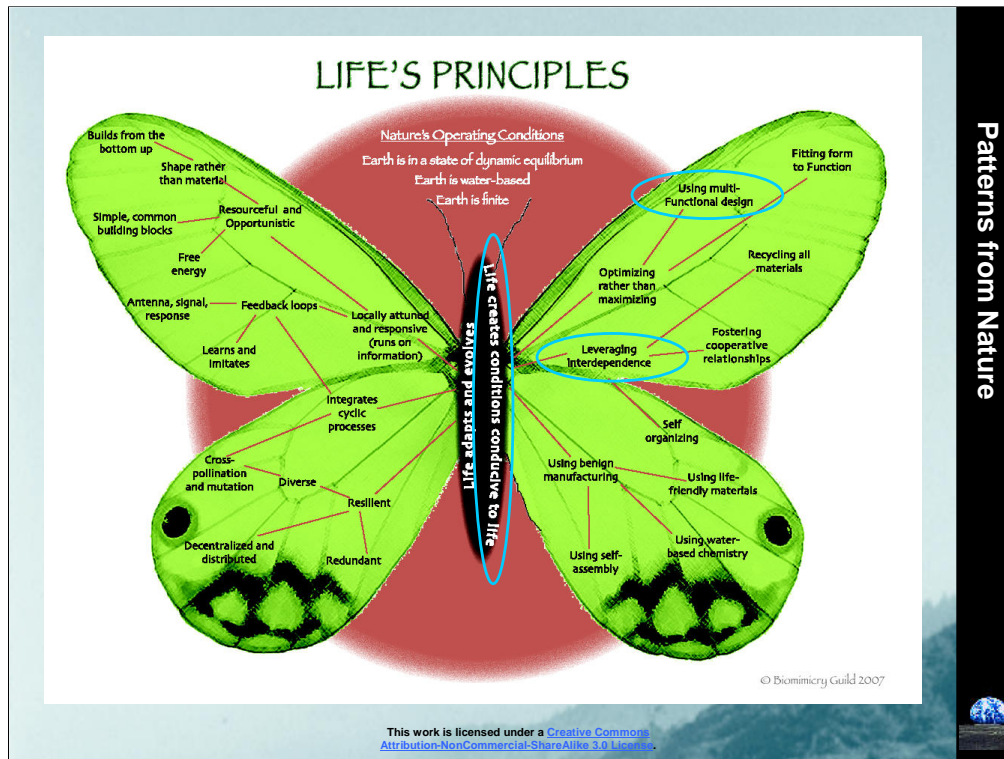
We initially focused on what patterns we could find in nature, but realised that this was limiting.

If natural and human systems have a strong degree of underlying commonality, then:

- transfer of knowledge from one to the other will be easier
- patterns (or anti-patterns) in human systems become a useful source of information
- we can integrate good human designs into the pattern language (‘off the shelf’ components assembled in new ways)

Usually, pattern languages are built from the ‘bottom up’.

We decided to adopt a ‘top down’ approach, to look for ‘deep patterns’ that could be applied to human challenges.



Ecosystems tend to:



- use materials effectively for multiple functions
- create conditions favorable to sustain life
- be made up of interdependent cooperative and competitive relationships (in progress – looking at food webs)

Talk about proto-patterns based on the first two

‘Proto-pattern’ in the sense of a ‘pattern in development’

- only dealing with one aspect of the ecosystem principle
- Significant work still required to make the pattern useful
- No track record: “useful, usable and used!” (Appleton)

Beetle vs. Candy Wrapper





“a composite of polysaccharides whose functions are achieved by altering the shape of the polymers, their alignment, and how they are bonded together”

“75-gauge polypropylene/ink/adhesive /60 gauge metallized-oriented laminate”

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Let us look at a example that is a bit closer to home, comparing chemistry on the right and biology on the left.

“Ecosystems tend to use materials effectively for multiple functions.”

Rolls off the tongue, but provides neither a reason nor a mechanism.

•Not clear what enforces such a principle.


•If it is such a good idea, why do we tend to use chemistry rather than structure?

Multi-Functional Materials

- **Problem:** Why do living systems structure common materials to meet a broad range of requirements, while we rely on chemistry?
- **Drivers:** Energy may be the most constrained resource in natural systems.
 - “... in technology, the manipulation of energy can account for up to 70% of the solutions to technical problems, whereas in biology energy never figures more than 5% of the time.” (Vincent, May 1/2007)

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Patterns from Nature



Starting to see the beginning of a pattern – because we can

What is the problem? Energy may be the most constrained resource on Earth

•“Two problems faced all pre-industrial economies in regard to energy: amount and concentration.” (Jack Goldstone)

•Sunlight is powerful, but diffuse and not always available when you need it (even photosynthesis needs to collect two photons)

•If concentrated, it quickly reaches temperatures that exceed point where protein coagulates

Multi-Functional Materials ...

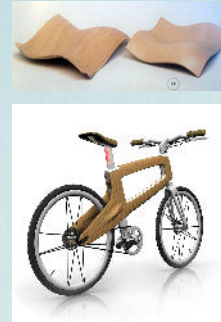
- **Therefore:** We should emphasise information over energy, leveraging inherent material structure
 - *“In technology we are outside the system. We destroy the information in the material (e.g. by processing, melting etc) then impose a new set of information (flow, moulding, casting) in order to end up with a product. ... In biology we are inside the system ... and the general scheme is to USE the information to generate the shapes / functions.”* (Vincent, May 1/2007)

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Multi-Functional Materials ...

- **Example:** the [JANO Dual Bike](#) made of molded wood veneer
 - stiffer than Fiberglas or Kevlar/epoxy composites
 - shock absorption of carbon fiber
 - responsiveness of steel
- **But:** Our ability to manipulate material structure is limited, although self-assembly techniques are becoming commercially viable.



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Wood veneer can be shaped in three dimensions, increasing stability and other functional characteristics, with 45% reduction in thickness.

•“Appearance of deep-drawn plastics or sheet metal”

“10 times stiffer than fibreglass and nearly 6 times stiffer than a kevlar/epoxy composite”

•“the ability to absorb bumps and road noise like carbon fibre”

•“the feel and responsiveness of steel”

•“enough lateral stiffness to provide a controlled and responsive ride”

Self-assembly is a rapidly growing field.

It is not only a technique for manipulating structure, but an example of using the inherent qualities of substrates and reactants.

“Conducive to Life”

- **Problem:** Healthy ecosystems are balanced, rich, diverse and vibrant communities of species, displaying interdependent, cooperative or symbiotic behaviours, *in spite* of natural selection.
- **Drivers:**
 - Natural selection works on organisms (no generally accepted theory at the ecosystem level)
 - “Survival of the fit” suggests competition, not cooperation/interdependency



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Numerous exceptions to “Life creates conditions conducive to life”


You would expect to see more of the negative ‘human’ behavior in ecosystems.

“Conducive to Life” ...

- **Therefore:** Explore how ‘order from disorder’ can emerge in systems, through study of principles underlying Self-Organizing, Hierarchical, Open systems
- **Examples:**
 - [Regen Energy](#) has developed autonomous, self-organizing power controllers based on [swarm theory](#)
 - ‘Embodied’ robots demonstrate greater adaptability and efficiency through *less* central processing

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Open systems through which high quality energy flows tend to display emergent properties and spontaneously self-organize (if other enabling conditions are satisfied).

•Life reverses entropy by using energy to maintain a state of non-equilibrium.


Swarm theory shows how order and complexity can arise from simple agents following simple rules.

“Conducive to Life” ...

- **But:**
 - The details of how systems self-organize are unclear, as are the other enabling conditions.
 - We lack good tools to analyze complex systems, although structured narratives or scenarios show promise.
 - Self-organizing systems may be inherently unpredictable, introducing uncertainty.

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Narratives (as stories) allow the listener to deal with varying scales of time and space.

Implications

- Energy is a key factor in all three proto-patterns explored so far
- Thermodynamics suggests energy is unique from other resources in that it cannot be fully recycled
- Humans use ‘heat pathways’ heavily
- A continuum of self-organizing processes
 - physical, chemical, biological
 - possibly cultural

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Materials can be recycled indefinitely, although it may be trapped in forms that are not easily accessible.

•“Materials cycle, energy flows” (Benyus?)

Work can be turned into heat, but heat cannot be converted into an equivalent amount of work.

- Ultimately rely on energy from sun and, to a lesser extent, on geothermal energy.
- Other forms of energy prone to depletion if usage exceeds rate of replenishment.

Most biological processes rely on chemical pathways, where heat is a byproduct (an exception is the bombardier beetle – Prof. McIntosh’s talk)

- allowed us to ‘step out of the game’
- explosive human development
- dependence on shrinking energy supplies

Research in Non-Equilibrium Thermodynamics suggests that self-organization is found across a wide range of systems

Are There Limits to Energy?

- “... *in technology, the manipulation of energy can account for up to 70% of the solutions to technical problems, whereas in biology energy never figures more than 5% of the time.*” (Vincent, May 1/2007)
- Our total metabolic rate far exceeds our internal rate, and exceeds what appears to be an ‘upper boundary’ in nature

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“Two problems faced all pre-industrial economies in regard to energy: amount and concentration.” (Jack Goldstone)

- Organisms appear to have a 40W/kg metabolic limit across a broad range of size
- Fossil fuels allowed us to exceed the limits of our internal metabolic rate (Reap)
- Internal metabolic rate of about 1-2W/kg
- External metabolic rate: UK 71W/kg, US 140W/kg, Canada 195W/kg


Earth’s systems likely ‘balanced’ at much lower rates of energy than what we use

Are There Limits to Energy?

- Increasing energy flows can push system past criticality into a chaotic or turbulent state
- Has our use of energy pushed our systems into a chaotic state, requiring ever more stringent controls to enforce stability?

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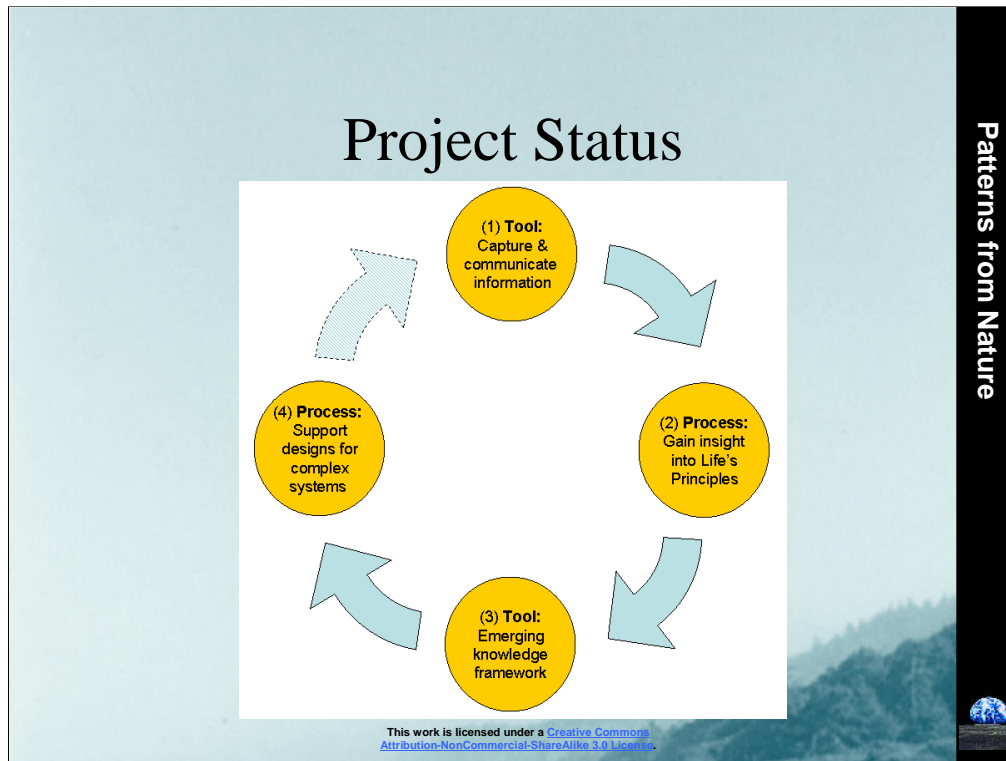
Pure speculation

As energy flows increase, systems can enter a state of chaotic or turbulent behaviour, which may be complex but does not contain useful information.

Interesting things happen ‘just this side’ of chaos. Dissipative systems appear to remain in a state of criticality, somewhere between stasis and chaos.

Are biological systems more energy efficient because they allow inherent or embedded stability to emerge?

- **Passive solar and other ‘low-tech’ solutions as a potential example**



Initially considered 'pattern language' as a tool/method to solve a specific problem:

- organise and communicate biological knowledge to disciplines other than biology

Became a process to gain insight into what the Life's Principles meant

- How do these insights relate to human challenges?

'Pattern language' can capture the evolving knowledge about complex systems

- What we know, and how can we apply it?
- where are the gaps, and how do we close them?

Pattern languages could also support design in complex, dynamic environments:

- encouraging practitioners to explore problems in depth, rather than jumping immediately into finding a solution.
- multi-scale aspect of pattern languages helps practitioners look at how their solutions 'fit' within the larger context
- communication and collaboration aspects help them deal with multiple stakeholders.

Parting Thoughts

- Key characteristics of pattern languages:
 - Informal: developed by and intended for people
 - Comprehensible: consistent pattern structure
 - Insightful: root causes of problems
 - Pragmatic: describe solutions known to work
 - Systems oriented: linked solutions to small problems help solve large problems

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Patterns from Nature



Informal:

- requires no complicated database or application
- common language
- narrative format

Parting Thoughts ...

- Pattern languages are seductively simple, but very hard to develop
 - need to demonstrate that they are “*Useful, usable, and used!*” (Appleton)
- ‘Top down’ approach does not lend itself to early practical applications
 - adding relevant examples
 - developing intriguing insights

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Acknowledgements

- Psychological Inertia:
 - © D. Mann: [Hands-On Systematic Innovation](#)
- The Conservation Economy:
 - © Ecotrust, <http://conservationeconomy.net>
- Pattern Language:
 - B. Appleton, [Patterns and Software: Essential Concepts and Terminology](#)
- Life's Principles:
 - D. DeLuca, © Biomimicry Guild

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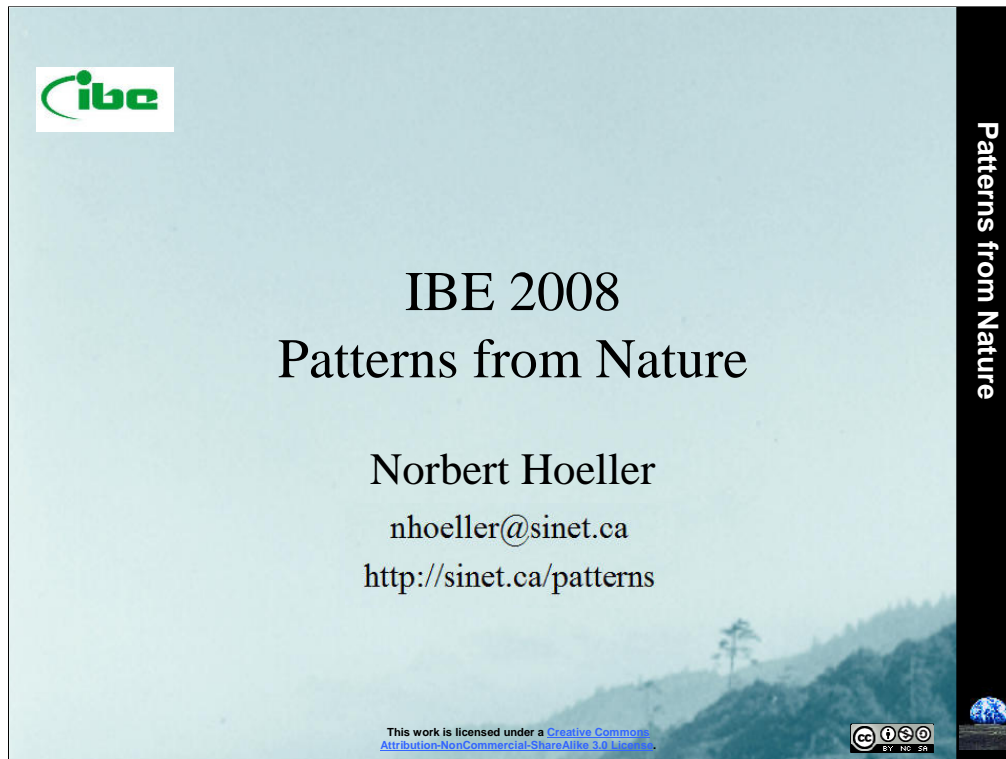


Acknowledgements ...

- beetle: © Igor Gorelchenkov – FOTOLIA
- candy bar: © Marc Dietrich – FOTOLIA
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- [JANO Dual Bike](#) – Roland Kaufmann
- Web of Life: [The Grinning Planet®](#)
- [Self-Organization, Embodiment, and Biologically Inspired Robotics](#) (Rolf Pfeifer, Max Lungarella, Fumiya Iida)
- Goldstone quoted by Diamond: [Guns, Germs and Steel](#)

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A key challenge facing the team is that our interest is not matched by our expertise in the areas that the project is exploring.

If you are interested in helping, please drop me an e-mail. We are particularly looking for expertise in non-equilibrium thermodynamics, exergy, ecosystem dynamics and self-organizing systems.

Q&A

Thank you for your attention!