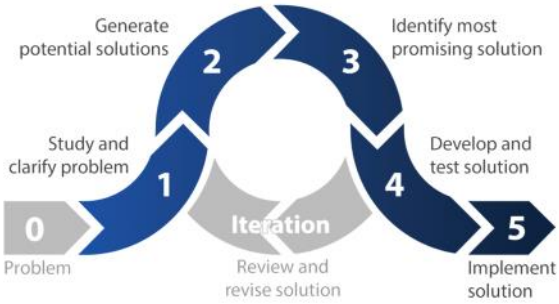
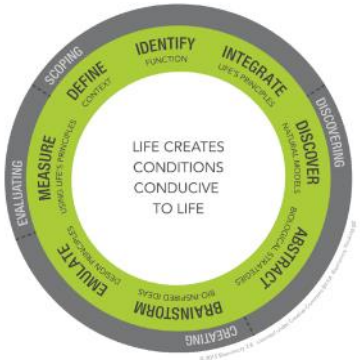
Module 5 - Lesson 2 - Biomimicry in Engineering Design
Sunday, October 23, 2022 11:56 PM

5.2.2 Biomimicry and Design

Conventional Engineering:



Biomimicry:



Biomimicry Design Process

- Stages:
  1) Scoping
  2) Discovering
  3) Creating
  4) Evaluating
- makes reference to "Life's Design Principles"

Biomimicry & Conventional Engineering

- both emphasize need to spend time on "front-end" of design process
- Conventional does not preclude an emphasis on nature

5.2.3 Life's Design Principles

EVOLVE TO SURVIVE	ADAPT TO CHANGING CONDITIONS	BE LOCALLY ATTUNED AND RESPONSIVE	INTEGRATE DEVELOPMENT WITH GROWTH	BE RESOURCE EFFICIENT (MATERIAL AND ENERGY)	USE LIFE-FRIENDLY CHEMISTRY
Continually incorporate and embody information to ensure enduring performance.	Appropriately respond to dynamic contexts.	Fit into and integrate with the surrounding environment.	Invest optimally in strategies that promote both development and growth.	Skillfully and conservatively take advantage of resources and opportunities.	Use chemistry that supports life processes.
Replicate Strategies that Work Repeat successful approaches. **Integrate the Unexpected** Incorporate mistakes in ways that can lead to new forms and functions. **Reshuffle Information** Exchange and alter information to create new options.	**Incorporate Diversity** Include multiple forms, processes, or systems to meet a functional need. **Maintain Integrity through Self-Renewal** Persist by constantly adding energy and matter to heal and improve the system. **Embody Resilience through Variation, Redundancy, and Decentralization** Maintain function following disturbance by incorporating a variety of duplicate forms, processes, or systems that are not located exclusively together.	**Leverage Cyclic Processes** Take advantage of phenomena that repeat themselves. **Use Readily Available Materials and Energy** Build with abundant, accessible materials while harnessing freely available energy. **Use Feedback Loops** Engage in cyclic information flows to modify a reaction appropriately. **Cultivate Cooperative Relationships** Find value through win-win interactions.	**Self-Organize** Create conditions to allow components to interact in concert to move toward an enriched system. **Build from the Bottom Up** Assemble components one unit at a time. **Combine Modular and Nested Components** Fit multiple units within each other progressively from simple to complex.	**Use Low Energy Processes** Minimize energy consumption by reducing requisite temperatures, pressures, and/or time for reactions. **Use Multi-Functional Design** Meet multiple needs with one elegant solution. **Recycle All Materials** Keep all materials in a closed loop. **Fit Form to Function** Select for shape or pattern based on need.	**Break Down Products into Benign Constituents** Use chemistry in which decomposition results in no harmful by-products. **Build Selectively with a Small Subset of Elements** Assemble relatively few elements in elegant ways. **Do Chemistry in Water** Use water as solvent.

The Earth's operation conditions:

- sunlight, water, and gravity | Dynamic non-equilibrium | Limits and boundaries | Cyclic processes

5.2.4 Consumer Products

- Example 1: Coloured Fabric without Chemical Dyes
  - Chemical dyes require pigment from nature, can be toxic, require energy to process & apply
  - Wings of Morpho butterflies refract light to create a brilliant blue colour
  - Teijin Fibers Ltd. created blue coloured fabric w/o chemical dyes by creating a fabric of varying thickness in a similar way that the Morpho butterfly wings are blue

- Example 2: Mussel & Gecko Adhesion
  - When wetted, most glues dissolve and lose their stickiness. Stickiness also loss with repeated sticking and unsticking
  - An adhesive has been synthesized that combines the way dry gecko work and the way wet mussel adhesion works, to create a product that is sticky on both wet and dry surfaces

5.2.5 Construction Materials

- Example 1: Self-Healing Concrete

5.2.3 Construction Materials

- Example 1: Self-Healing Concrete
  - Repairing concrete by conventional methods creates pollution and uses energy
  - This new form of concrete uses microfibers in place of coarser bits of sand and gravel that traditional cement mixes use.
  - Fibers allow final composite to bend with minimal fracturing, and if fracturing occurs, they tend to be less than 50 microns wide
  - When cracks form, the dried concrete absorbs moisture from the air. The concrete in the crack becomes softer and eventually "grows" until the crack is filled in
  - Calcium ions within the crack absorb moisture along with CO_2 from the air
  - This forms a calcium carbonate material similar to those found in seashells
  - This regrowth & solidifying of calcium carbonate renews the strength of the cracked concrete

- Example 2: MAP Cement Making
  - Mineralization via Aqueous Precipitation (MAP) inspired by coral polyps
  - Instead of releasing CO_2, the MAP process sequesters carbon from coal-fired power plants & other gaseous waste steams containing high concentrations of GHGs.