

**ENGS 44**  
**SUSTAINABLE DESIGN**

**Sustainable Design Principles**

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*“Our current age sees everything as an object of manufacture, as something which can be got hold of and improved, or altered, to produce better or more effective outcomes. This is our present fate, especially in the West, to understand all things in this way.”*

Laurence Paul Hemming  
in *Worship as Revelation*  
burns & oates, 2008, page 10.

So, we seek to *improve* and *alter*, even *disrupt* .  
We love to design and redesign.  
Buzz words today are *innovation* and *disruption*, both considered as positive.

The question is: How can we design and redesign responsibly?

What should be the guiding principles?



## Underlying principle

We don't design for the sake of designing.

We design for a purpose:

- To meet a need  
in a new way,  
in a better way,
- To achieve a goal,
- To make a statement.



This holds true regardless of the size of what is being designed, from a bicycle shed to an entire city, from a spoon to a cell phone.

*"If you cannot measure it, you can't improve it."*

Lord Kelvin



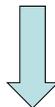
*"We cannot solve our problems with the same thinking we used when we created them."*

Albert Einstein



Conclusions:

- We need to be quantitative → engineering sciences
- We need to think creatively → some art involved



**The Science and Art of Sustainable Design!**

## Principles of Sustainable Design

according to Jason F. McLennan, "*The Philosophy of Sustainable Design*", 2004

1. Learning from natural systems  
(Biomimicry Principle)
2. Respect for energy & natural resources  
(Conservation Principle)
3. Respect for people  
(Human Vitality Principle)
4. Respect for place  
(Ecosystem Principle)
5. Respect for future  
(“Seven Generations” Principle)
6. Systems thinking  
(Holistic Principle)

There are other lists of Sustainable Design Principles:

(See Chapter 5 of *The Sustainability Revolution – Portrait of a Paradigm Shift* by Andres R. Edwards, 2005)

### **The Hannover Principles** (McDonough & Braungart)

Insist on rights of humanity and nature to co-exist.  
Recognize interdependence.  
Respect relationships between spirit and matter.  
Accept responsibility for consequences of design decisions.  
Create safe objects of long-term value.  
Eliminate the concept of waste.  
Rely on natural energy flows.  
Understand limitations of design.  
Seek constant improvement by the sharing of knowledge.

### **Principles of Ecological Design** (Van der Ryn & Cowan)

Solutions grow from place.  
Ecological accounting informs design.  
Design with nature.  
Everyone is a designer.  
Make nature visible.

### **Principles of Ecological Design** (John and Nancy Todd)

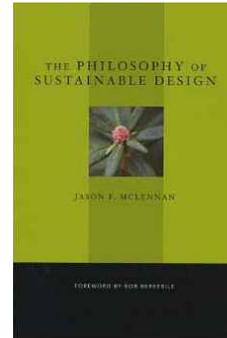
1. The living world is the matrix for all designs.
2. Design should follow, not oppose, the laws of life.
3. Biological equity must determine design.
4. Design must reflect bioregionality.
5. Use renewable energy sources.
6. Proceed by integration of living systems.
7. Design should be co-evolutionary with nature.
8. Building and design should heal the planet.
9. Design should follow a sacred ecology.

... and this list is not exhaustive.

**We follow here the Principles of Sustainable Design**

according to Jason F. McLennan, "*The Philosophy of Sustainable Design*", 2004

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**Learning from Nature (Biomimicry Principle)**

**Nature as model** (Janine Benyus, "*Biomimicry*", 1996)

- Nature runs on sunlight.
- Nature fits form to function.
- Nature recycles everything.
- Nature rewards cooperation.
- Nature banks on diversity.
- Nature relies on local expertise.
- Nature curbs excesses within.



← Quite a contrast with the way we conduct our affairs today...

**Nature as measure**

- Nature suggests relative abundances and balances.
- Nature demonstrates achievable rates.
- Nature shows limits.

**Nature as mentor**



- The Italian CAMP pick ax is modeled after the woodpecker. →
- The nose of the Concorde supersonic plane was designed to be lowered on approach like the head of a swan.
- Velcro is a carbon copy of how seeds stick to animal hair.
- Kevlar in bullet-proof vests is inspired by spider silk.



[www.fastcompany.com/magazine/128/truly-intelligent-design.html](http://www.fastcompany.com/magazine/128/truly-intelligent-design.html)

## Several bio-inspired robots



Octobot (Harvard): All soft mechanical components and autonomous



Six-legged robot (Hexa): Able to scale steps and balance on uneven ground



Pleurobot (EPFL): Mimics the motion of a salamander with a unique vertebrate that allows the robot to slither in and out of the water.



Snakebot (Carnegie Mellon University): Inspired by sidewinders to be able to crawl through rubble and around obstacles.



Bipedal Bot (Agility Robotics): Based on the anatomy of ostriches.



Spot (Boston Dynamics): Need to mention the inspiration?

(Source: [www.machinedesign.com/motion-control/7-bio-inspired-robots-mimic-nature](http://www.machinedesign.com/motion-control/7-bio-inspired-robots-mimic-nature))

## The economy of sustainable design

*"Nature does nothing uselessly."*  
Aristotle

*"Human subtlety will never devise an invention more beautiful, more simple or more direct than does Nature, because in her inventions, nothing is lacking and nothing is superfluous."*  
Leonardo da Vinci

Let these quotes serve not only as a call for humility but also as a useful definition of optimization.

The optimal design is one in which  
- Nothing is lacking, and  
- Nothing is useless or superfluous ... just as Nature does.

It is useful to return to these fundamental attributes when nearing the completion of a new design. Then, ask:

- Does my design lack anything?
- Does my design include useless or superfluous components?



Here, do the in-class exercise on bio-mimicry

## Respect for Energy and Natural Resources (Conservation Principle)



Almost all energy on earth comes from the sun or came from the sun at one time.

The amount is staggering: The sun shines on earth every day enough energy to meet our electrical demand for 27 years!

But, solar radiation is dispersed, and some concentrating and storage mechanisms are required. Nature provides numerous examples of energy concentration and storage:

- physical processes
  - hydrologic cycle (providing water elevation → potential energy)
  - winds and currents (movement → kinetic energy)
- biological processes
  - solar energy captured by plant leaves (photosynthesis)
  - food web concentration (higher forms of life eating lower forms)
- chemical processes
  - food calories ↔ ATP in our bodies



And what do we humans do? Instead of doing likewise, we use non-renewable stored forms of energy (coal, petroleum and natural gas). We also consume energy at wasteful rates.



Ditto with materials: We extract and heavily process non-renewable materials, and we tend to use much more material than we strictly need.

## Respect for People (Human Vitality Principle)

Most of the American infrastructure and buildings in the 20<sup>th</sup> century can be characterized as **utilitarian**, and much is unfriendly.

Houses, factories and office buildings with all their electromechanical subsystems are more akin to **machines** in which we live, produce and work than **habitats**.

And sometimes, the “machine” does not even work well.  
This is why we have the expression “sick building”.



We have designed hospitals that are health-care factories, apartment buildings that “park” people, cell phone games that discourage a sense of community, and automobiles in which we spent more time by ourselves than ever before.

Sustainable Design, by contrast, aims to create healthy and nourishing places.

*“It is about honoring diversity and giving control back to people for their environments and personal comfort.”*

Jason McLennan, *“The Philosophy of Sustainable Design”*, 2004



### Questions:

What is nourishment?  
What is comfort?  
What is well being?

Search for answers in the context of  
the building in which we now are.

## Respect for Place (Ecosystem Principle)

Sub-principles: Adaptation to the local environment  
Treading light on the place  
More is not better; closer fit is better.

Traditional cultures and buildings have been inspired by place.  
This has been called **Vernacular Architecture**.



Rural dwelling in Indonesia  
Use of local wood.  
Natural ventilation in humid climate.  
Elevation to guard against wild animals.  
(<http://www.istockphoto.com/>)



Villages in southern Belgium  
Use of local stone and slate.  
Facades oriented South for heat gain.  
Grouped building arrangement to save heat and  
leave more open space for cultivation.  
(<http://users.belgacom.net/LaSeigneurie/airphoto.htm>)

Sustainable school building made of bamboo in Bali



Talk by Elora Hardy at:

<http://www.inktalks.com/discover/116/elora-hardy-building-a-sustainable-bamboo-future>

## Respect for Place, cont'd (Ecosystem Principle)

Other examples of symbiosis with the local environment, this time expressed in the building's exterior shape...



**Kieran Timberlake's Loblolly House:**  
Positioned between a dense grove of loblolly pines and a lush foreground of saltmeadow cordgrass along the Chesapeake Bay, this house echoes the elements of trees, tall grasses, the sea, the horizon, the sky and the western sun that characterize the place.  
([http://www.kierantimberlake.com/featured\\_projects/loblolly\\_1.html](http://www.kierantimberlake.com/featured_projects/loblolly_1.html))

... or interior elements



**A church amidst trees**  
The interior of this church was designed to blend with its exterior, forcing occupants to be mindful of their context. An idea expressed here is a religious one: Thanksgiving to God (inside) for his creation (outside). (forgotten source)

## Respect for Place, cont'd (Ecosystem Principle)

Additional examples



**Mosque of Bougouni (circa 1890) in Mali:**  
Use of ostrich eggs – symbolic of purity and fertility – both as a decoration and as protection against heavy rain. Thick walls and small windows to stay cool inside.  
([http://sirismm.si.edu/eeepa/eeep1/eeepa\\_16094.jpg](http://sirismm.si.edu/eeepa/eeep1/eeepa_16094.jpg))



**Inuits' winter igloo:**  
Use of local and renewable material. Spherical shape to maximize volume to surface ratio (= minimization of heat loss). Double use of material for structure (strength) and cover  
([www.tslr.net/2008/05/inuit-igloo.html](http://www.tslr.net/2008/05/inuit-igloo.html))



- Respect land's fragility. Some land is too fragile for building.
- There is also in each of us the need to "come from somewhere".

Here, read story on search for the Northwest Passage  
("Sustainable by Design" by Stuart Parker, pages 30-31)

### **Respect for Future** **("Seven Generations" Principle)**



There is no escape from time.

Nature is governed by temporal rates (solar radiation, tree growth, bacterial decay, ...).  
Everything we do has a consequence in the future. There are multiple ripple effects.

What we consume is no longer there for later,  
unless it is renewable and consumed at a rate below replenishment.

What we waste away has to go somewhere, where it will later have an impact.

*"In our every deliberation we must consider the impact of our decisions on the next seven generations."*

From the Great Law of the Iroquois Confederacy,  
as quoted and used by Seventh Generation (<http://www.seventhgeneration.com/>)

Example of working with nature in a very tangible way:

Living bridges in Meghalaya, India



See:

[https://www.youtube.com/watch?v=KD\\_iidGaWcl](https://www.youtube.com/watch?v=KD_iidGaWcl)

## Systems Thinking (Holistic Principle)



This is evident to see but hard to practice.

The fact that everything is ultimately linked to everything else on earth causes problems when we design new products and buildings.

We need to consider the impacts of our designs, but do we stop in considering the sequence of effects?

When a limit has been reached or consequences become unacceptable, change is needed upstream. But where?

Rarely is an effect caused by a single action. Most often effects are traced to multiple sources, if these sources are discernable at all.

In **Sustainable Design**, it is further imperative to consider impacts not only on the environment (ecology) but also on people (equity) while simultaneously minding the business aspects of the activity (economy).

RECOMMENDED VIDEO:

Affordable Green Housing

[https://search.alexanderstreet.com/view/work/bibliographic\\_entity%7Cvideo\\_work%7C2362343/affordable-green-housing](https://search.alexanderstreet.com/view/work/bibliographic_entity%7Cvideo_work%7C2362343/affordable-green-housing)