Design in the Age of Biology:
Shifting from a Mechanical-Object Ethos to an Organic-Systems Ethos
We are in the midst of a fundamental shift in how we view the world—and how we explain it.
From ...

A causes B
and B causes C

To ...

A causes B, C, D, E, + F
and F causes G, H, I, J, + K
and K causes L, M, N, O, + P
and P loops around to cause A

i.e. A causes B
and B causes A
from Newton to Darwin
from Industrial age
to Information age
Where did we start?
Mechanical clocks appeared in Europe about 1400; since then, mechanics have been our foundational metaphor.
The Copernican view of the world is essentially mechanical.
Biology is our new foundational metaphor.
“... biotechnology will dominate our lives and our economic activities during the second half of the 21st century, just as computer technology dominated our lives and our economy during the second half of the 20th.”

— Freeman Dyson
What changed?
In 1837, Karl Ernst von Baer compared development of embryos of various animals.
In 1859, Charles Darwin published *Origin of Species.*
In 1865, Gregor Mendel wrote about his studies on genetic traits in *Experiments on Plant Hybridization.*
In 1902, Pyotr Kropotkin published *Mutual Aid: A Factor of Evolution*—cooperation as a way to create advantage.
In 1947, Rosalind Franklin took an x-ray of DNA, leading to Watson and Crick creating the double helix model.
In 1976, Richard Dawkins published *The Selfish Gene* coining the term “meme” (a unit of cultural transmission or imitation), suggesting that ideas evolve.
In 2000, the Human Genome Project and Celera announced sequencing of a human genome.
In 2002, Fred Hughston, Bonnie Bassler et al. discover that bacteria communicate and coordinate—quorum sensing, acting when a colony is large.
The next great frontier is cellular pathway signaling.
The shift in world view coincides with a shift in our view of products.
from Hierarchical and closed to Distributed and open

See Eric Raymond’s essay, “The Cathedral and the Bazaar”
from Complete edition to Continuous beta
from Objects to Experiences
“... commercial products are best treated as though they were services.

It’s not what you sell a customer, it’s what you do for them.

It’s not what something is, it’s what it’s connected to, what it does.

Flows become more important than resources. Behavior counts.”

— Kevin Kelley, Out of Control
What changed?
Systems are everywhere.

Columbia Broadcasting System (CBS)

Federal Reserve System

Herman-Miller Action Office System

Honor System

Immune System

Linux Operating System

Mojave Desert Ecosystem

Schiphol Airport Signage System
Systems affect many dimensions of design.

- Creating and managing (networked) services
- **Connecting** products + services
- **Integrating** across products
- Building a seamless **brand experience**
- Communicating with **consistency**
- Creating **sustainable** businesses (green design)
Hardware products are increasingly tied to:

- embedded **software**
- the **internet** and web-based applications
- human **services**
- the **organizations** which develop and deliver the products and services
- **communities** for which they provide infrastructure
- the **ecologies** in which they cooperate and compete
Value comes from interacting with larger systems—enabling an ecology.

— John Rheinfrank & Fred Murrell
iPod is an integrated system.

DRAM > mp3 player > music sharing service > my music
Smartphones are becoming hubs of body-area networks.

**New/Additional sensors and actuators**
- Blood glucose
- Blood pressure
- Cholesterol
- Heart rate
- Hydration
- Weight
- Medication dosing and monitoring e.g., insulin pump

**Reinvent meter as health status tracker**

**Networked enabled services supported by subscription**
- Connecting with caregivers (e.g., Family, Physician)
- Joining communities for support and learning
- Engaging with wellness coach for behavior change

**Body Area Network Hub**

**Personal Computer**
Amazon’s Kindle-Reader-WisperNet-Store system is another networked-services ecology.

“I think of [the Kindle] as a service. Part of [it] is of course the hardware, but really, it’s the software, the content, it’s the seamless integration of those things.”

— Jeff Bezos
The shift in the nature of products requires a shift in the way we design.
from
Expert/patient
to
‘Symmetry of ignorance’
from Perfecting to Growing
<table>
<thead>
<tr>
<th>From ...</th>
<th>To ...</th>
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<tbody>
<tr>
<td>escaping the past</td>
<td>inventing the future</td>
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<tr>
<td><strong>Manufacturing Age</strong></td>
<td><strong>Age of Biology</strong></td>
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<tr>
<td><strong>Objects/Things</strong></td>
<td><strong>Systems/Behaviors</strong></td>
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<tr>
<td><strong>Seek simplicity</strong></td>
<td><strong>Embrace complexity</strong></td>
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<tr>
<td><strong>Expert/Deciding</strong></td>
<td><strong>Collaborator/Facilitating</strong></td>
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<td><strong>Direct</strong></td>
<td><strong>Mediated</strong></td>
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<tr>
<td><strong>Almost perfect</strong></td>
<td><strong>Good enough for now</strong></td>
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<tr>
<td><strong>More deterministic</strong></td>
<td><strong>Less predictable</strong></td>
</tr>
<tr>
<td><strong>Completed</strong></td>
<td><strong>Adapting continuously</strong></td>
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What does this mean?
Nodes—Nouns—Objects.
Links—Verbs—Systems.
Hydrologic Cycle.
Cradle to Cradle.

—McDonough and Braungart
Thinking in terms of whole systems means

- Building **relationships** between products
  e.g. roadmaps, product lines, platforms, APIs

- **Continuous change** + dynamic development
  e.g. stocks, flows, lags, oscillation

- Enabling **feedback**
  e.g. goal-action-measure-compare loops

- Adopting **metaphors from nature**
  e.g. ecology, evolution, emergence
How do we get there?
Design education focuses on the **form of objects**; much of practice does likewise.
Form is governed by meaning and structure, though they are also affected by form.

**What** are we making?
Meaning/Definition
Semantic

**How** are we making it?
Form/Grammar
Syntactic

**Object**
Component
Meaning + structure are governed by context; context is also affected by meaning + structure.

**Why** are we making this?
Context/Need
Pragmatic

**What** are we making?
Meaning/Definition
Semantic

**How** are we making it?
Form/Grammar
Syntactic

**Object**
Component
Objects are often embedded in systems.

**Why** are we making this?
- Context/Need
- Pragmatic

**What** are we making?
- Meaning/Definition
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**How** are we making it?
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**Object**
- Component

**System**
- Systems of components
- Organism
Systems are often embedded in ecologies—communities of systems.

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<th>Object Component</th>
<th>System Systems of components Organism</th>
<th>Ecosystem Systems of systems Community Market</th>
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Dubberly Design Office · Design in the Age of Biology · 22 October 2012
Practice focused on the form of objects can be **direct and unmediated**.

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As practice expands, it becomes more complex.
When practice also concerns context + ecologies, project **teams** require **many disciplines**.

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- **Object**: Component
- **System**: Systems of components
  - **Organism**
- **Ecosystem**: Systems of systems
  - **Community**
  - **Market**

**Team**
- **Explicit**
- **Shared**

**Individual**
- **Intuitive**
- **Idiosyncratic**
Moving our focus from the form of objects to the behavior of systems requires research.

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Twentieth century design education focused largely on the form of objects.

Twenty-first century design practice already focuses largely on the behavior of systems.

Let’s (re-) imagine design education from a system’s perspective.
Systems courses might be organized into six broad categories:

- Formal
- Resource distribution
- Dynamic
- Control
- Living
- Conversation
Formal systems

- Sequence and proportion
- Tiling, packing, and patterns
- Combination and permutation
- Fractals and cellular automata
- Information structures
Systems for resource distribution

- Chance and probability
- Exchange systems
- Matching systems
- Voting systems
Dynamic systems

- Stocks and flows
- Resource cycles
- Lags and oscillations
- Explosions and collapses (vicious and virtuous cycles)
- Dynamic equilibrium and homeostasis
Control systems

- Simple feedback
- Requisite variety
- Stability
- Goal-task hierarchies
- Multi-level feedback
Living systems

- Dissipative systems
- Autopoiesis
- Co-evolution and drift
- Bio-cost
Systems for conversation
- Platforms, construction sets, and languages
- Understanding and agreement
- Learning and play
- Ethics, choice, and responsibility
Special thanks to
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