Design in the Age of Biology:

Shifting from a Mechanical-Object Ethos to an Organic-Systems Ethos

Hugh Dubberly
Dubberly Design Office

We are in the midst of a fundamental shift in how we view the world— and how we explain it.
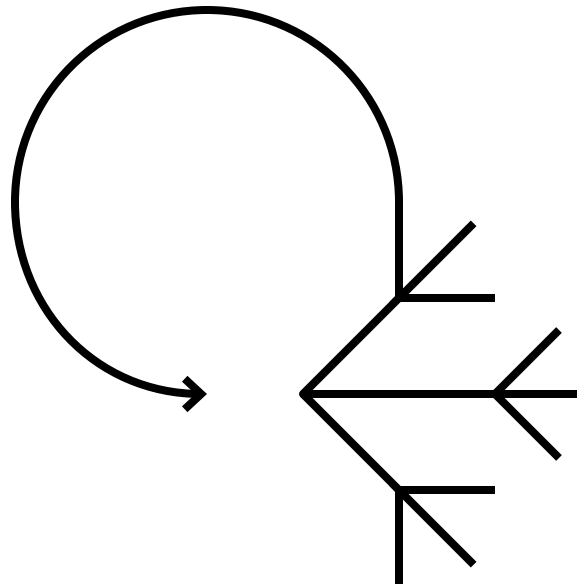
From ...

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
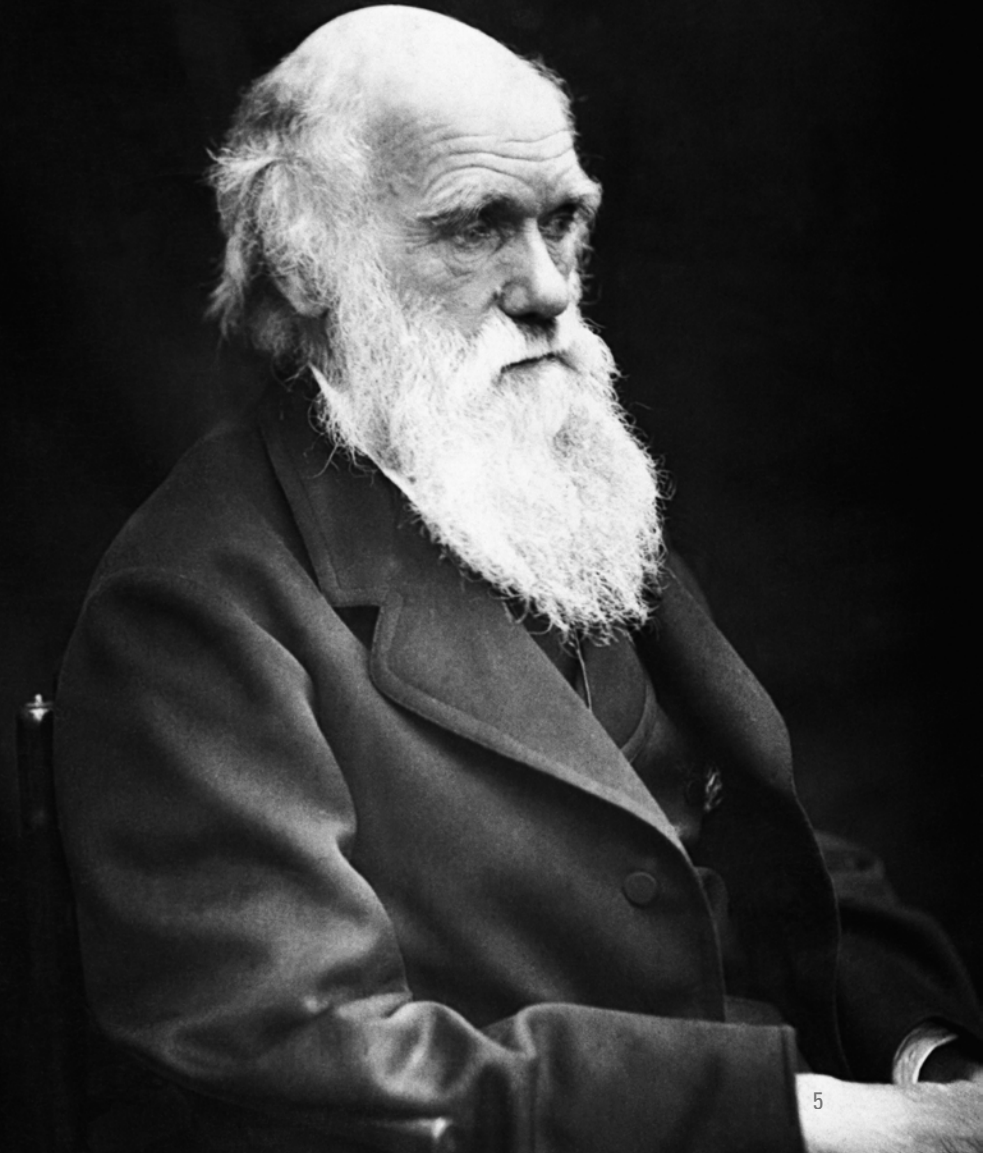
**i.e. A causes B
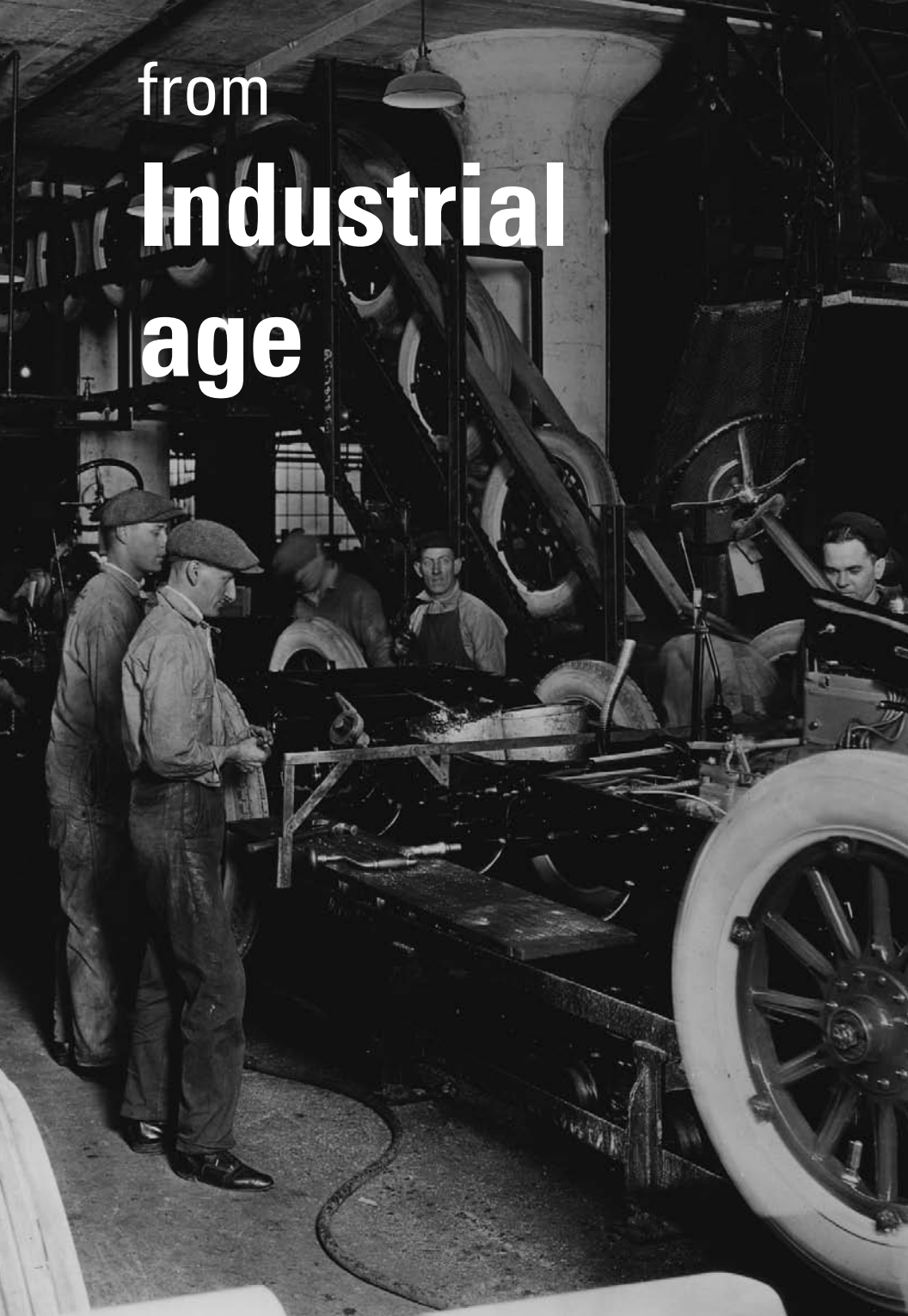and B causes A**

from
Mechanical

to
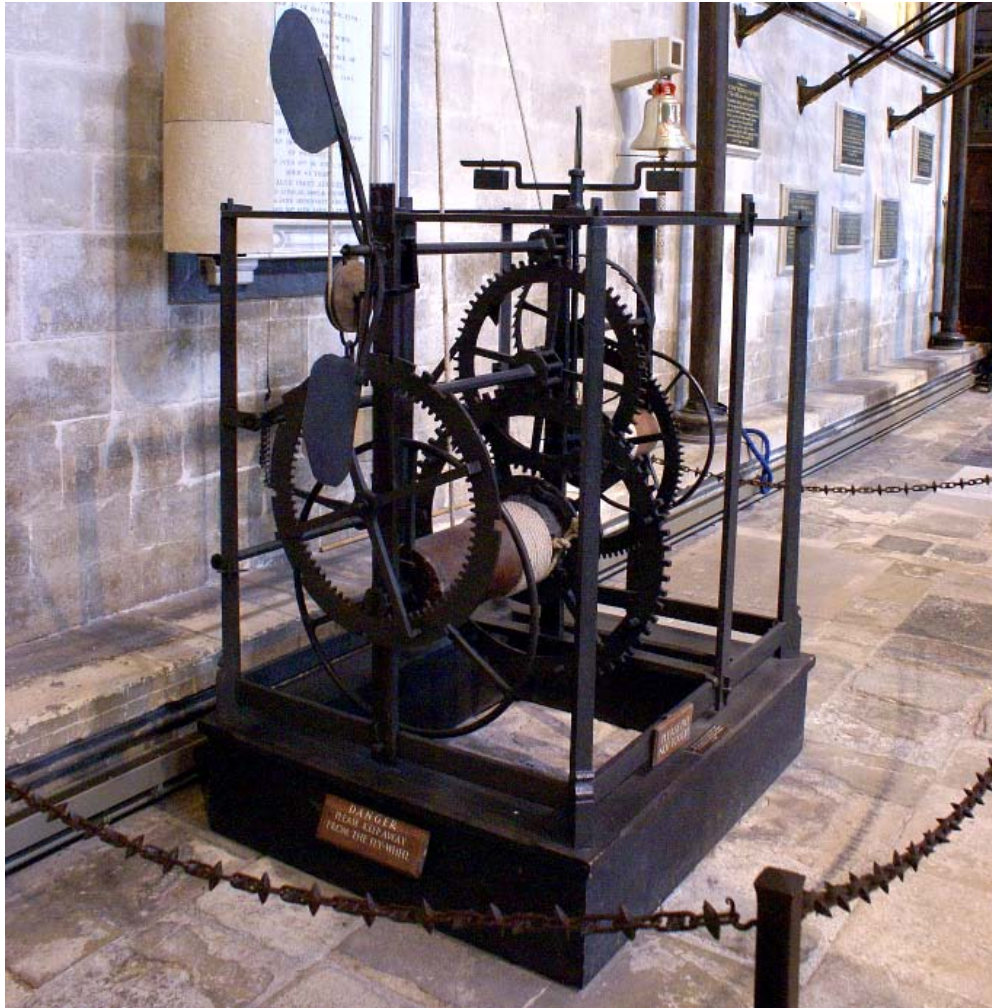# Biological

from
Newton

to
Darwin

from
Industrial age
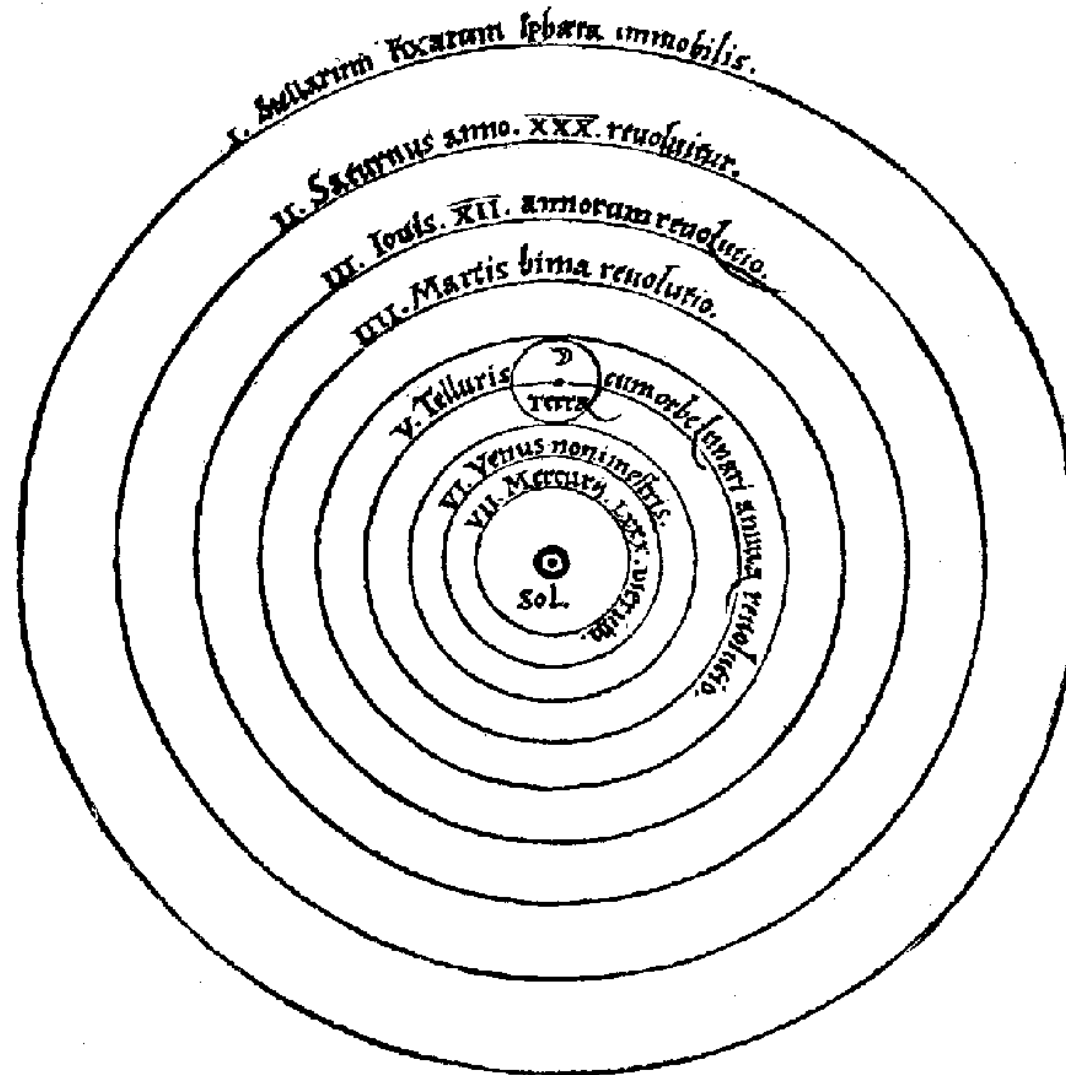
to
Information age

Where did we start?

Mechanical clocks appeared in Europe about 1400; since then, mechanics have been our foundational metaphor

Oldest working modern clock, located in Salisbury Cathedral, England

The Copernican view of the world is essentially mechanical.
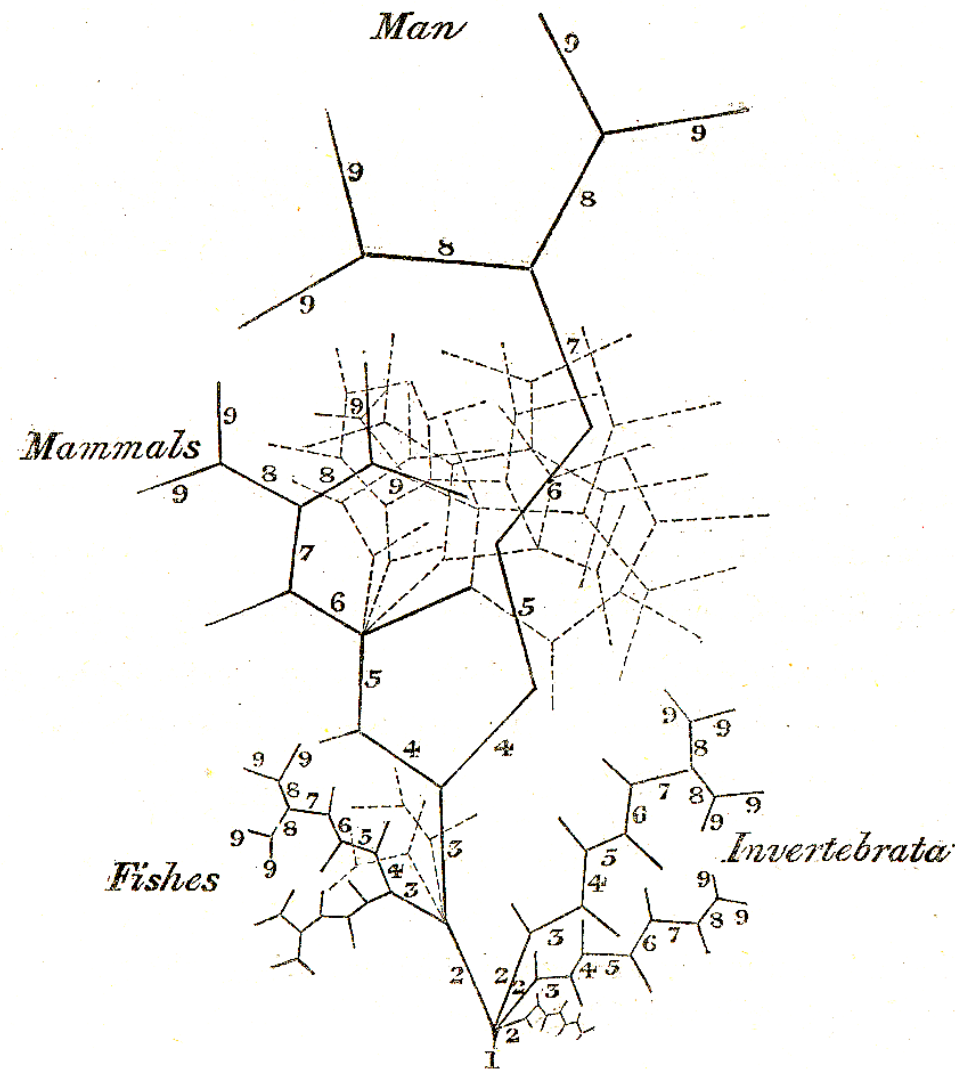
Biology is our new foundational metaphor.

"*. . . 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."

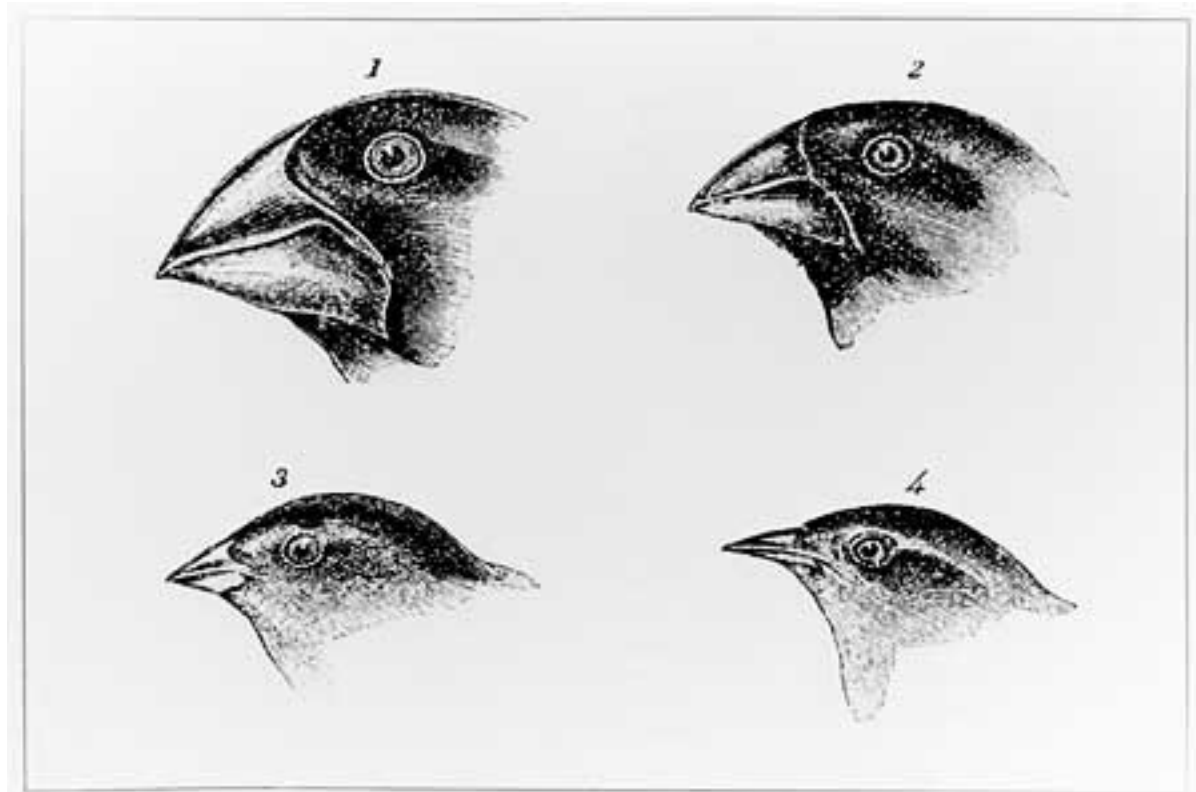— Freeman Dyson

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.*
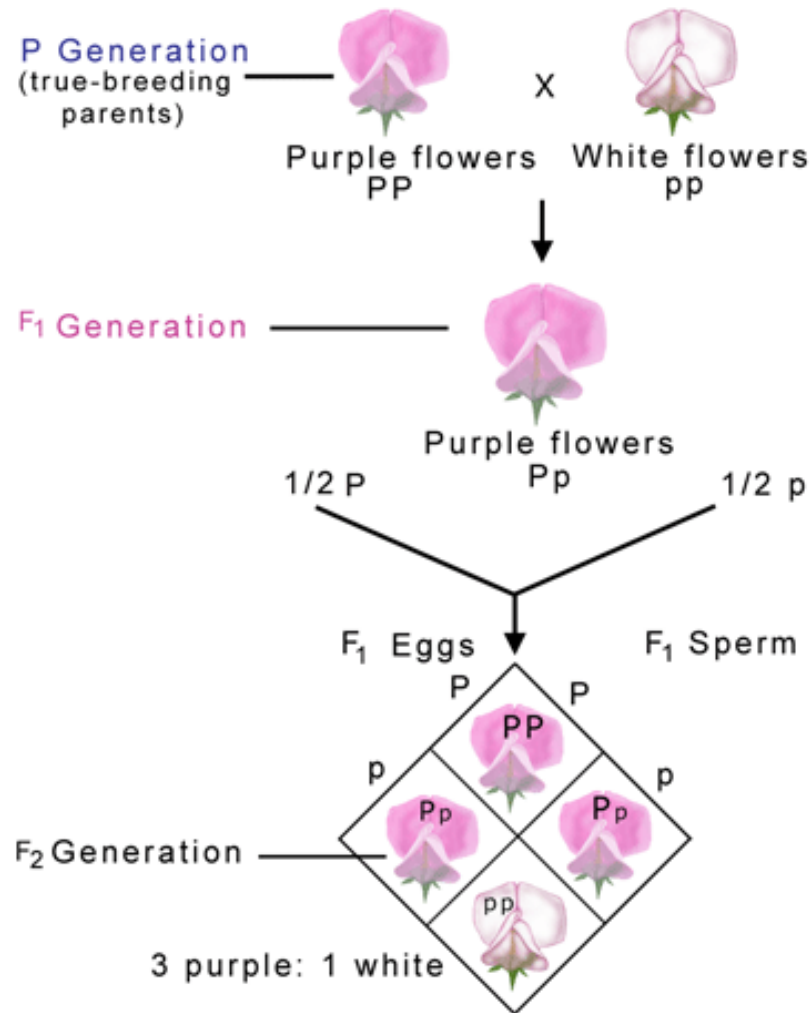
In 1902, Pyotr Kropotkin published *Mutual Aid: A Factor of Evolution*— cooperation as a way to create advantage.

In 1947, Rosalind Franklin took an x-ray of DNA, leading to Watson and Crick creating the double helix model.
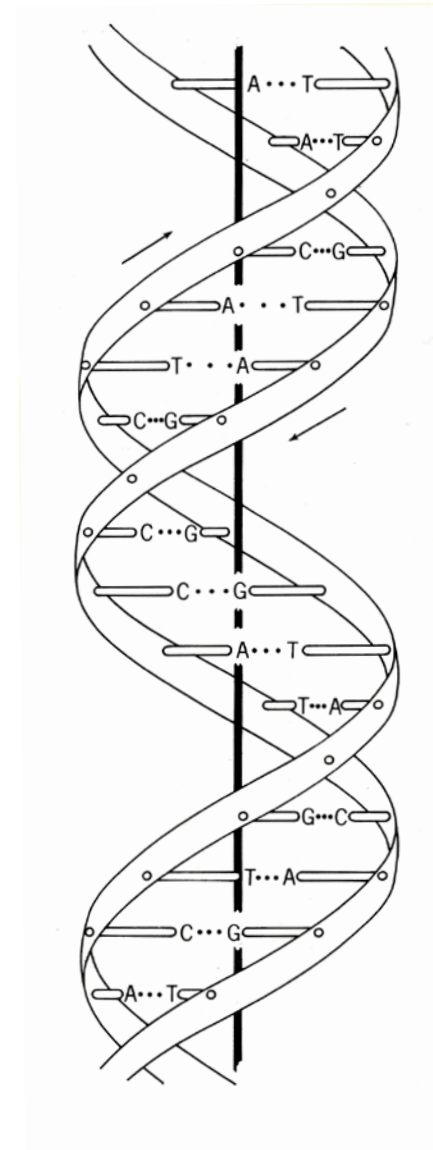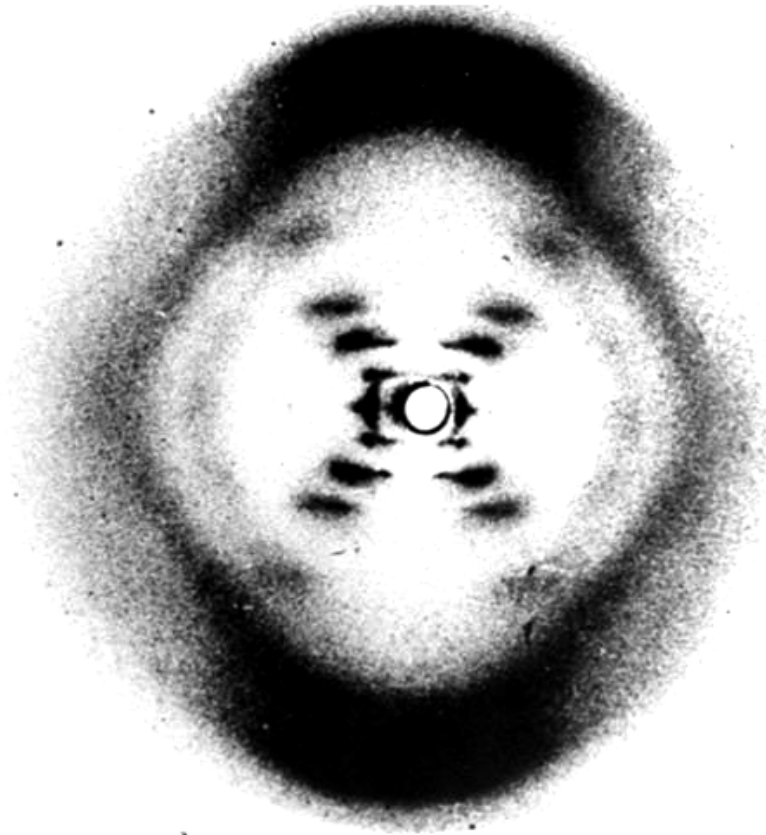
**In 1976, Richard Dawkins published
The Selfish Gene coining the term "meme"
(a unit of cultural transmission or imitation),
suggesting that ideas evolve.**

In 1999, Susan Blackmore published *The Meme Machine* coining the term "technological meme," or "teme," self-reproducing technology.
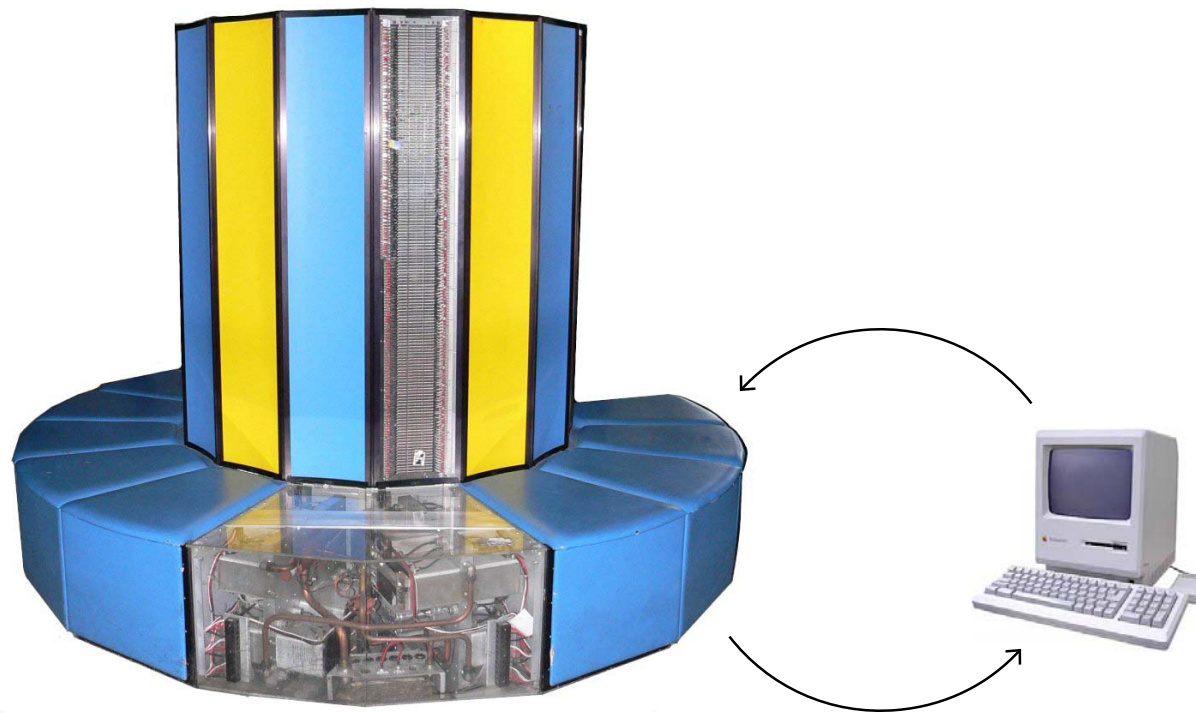
In 2000, the Human Genome Project and Celera announced sequencing of a human genome.
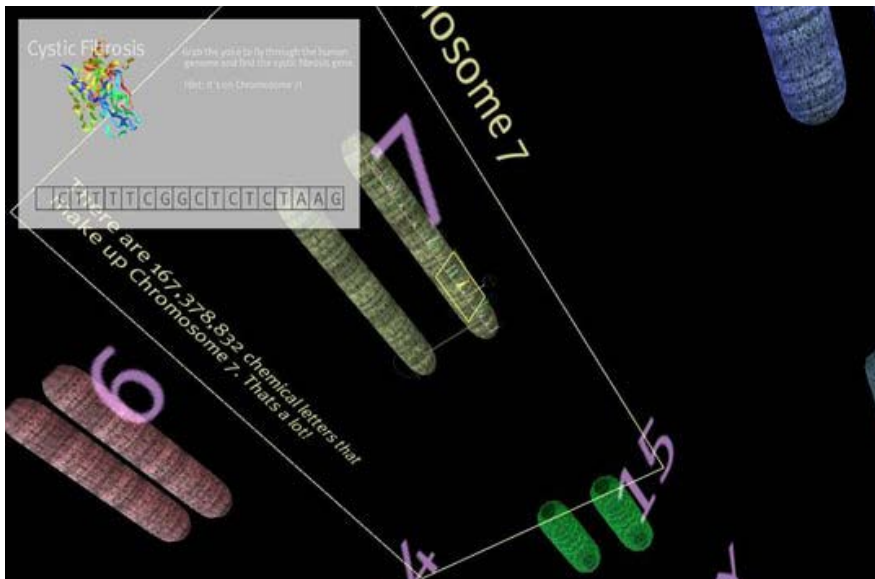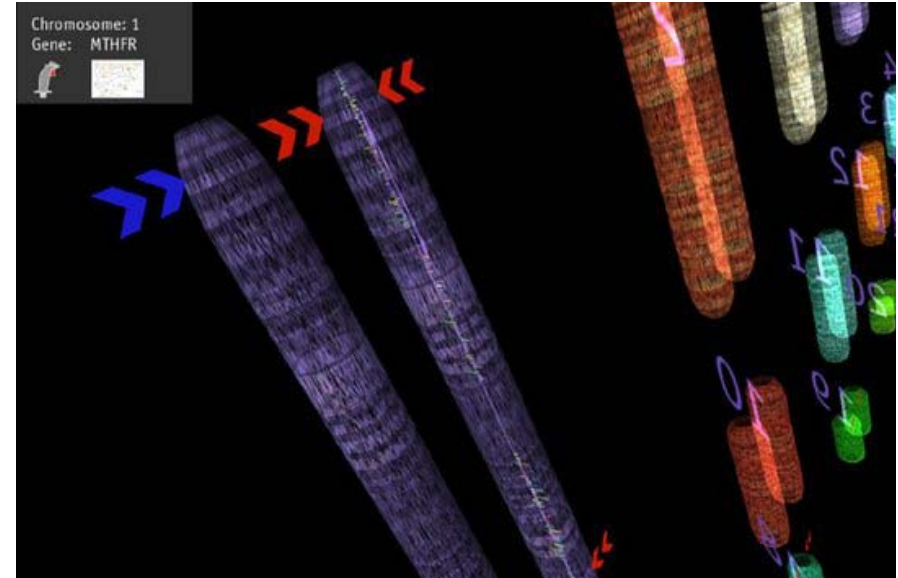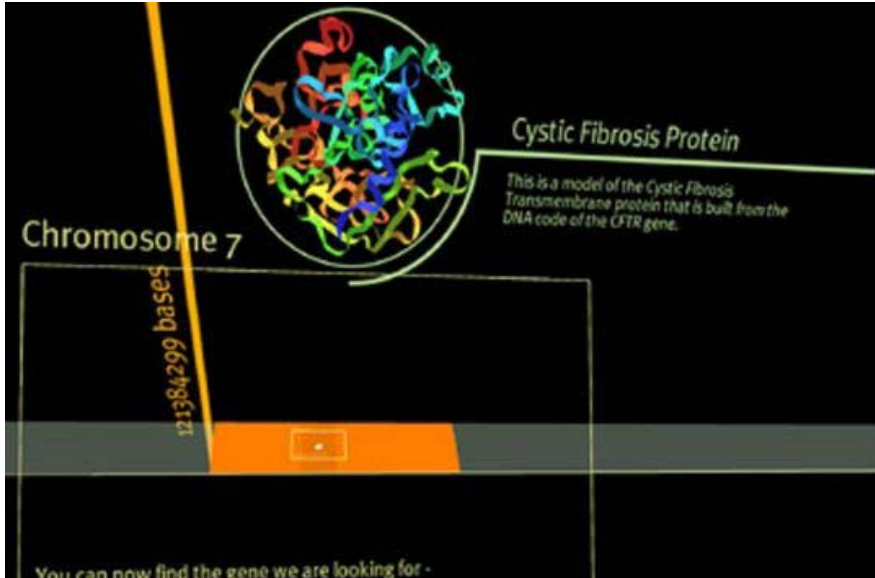
In 2002, Fred Hughston, Bonnie Bassler et al. discover that bacteria communicate+coordinate— quorum sensing, acting when a colony is large.
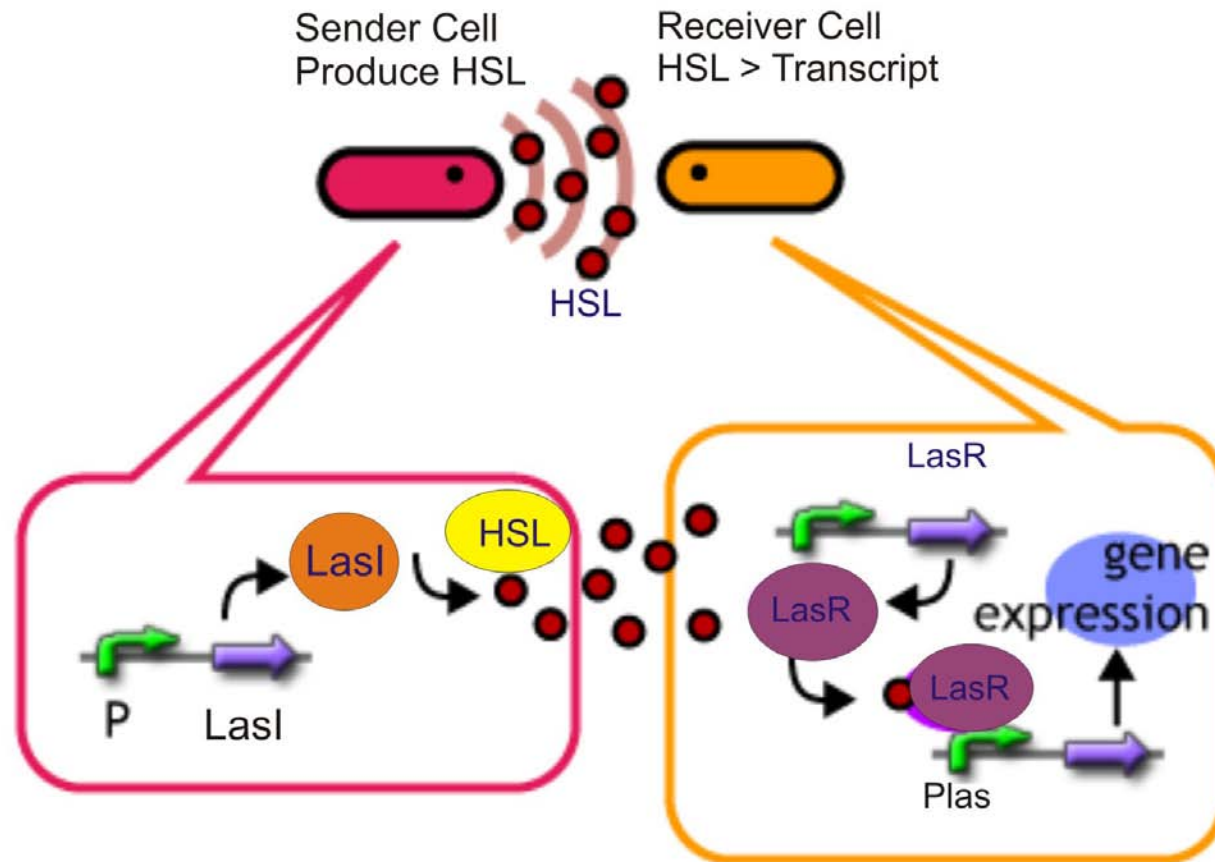
The next great frontier
is cellular pathway signaling.
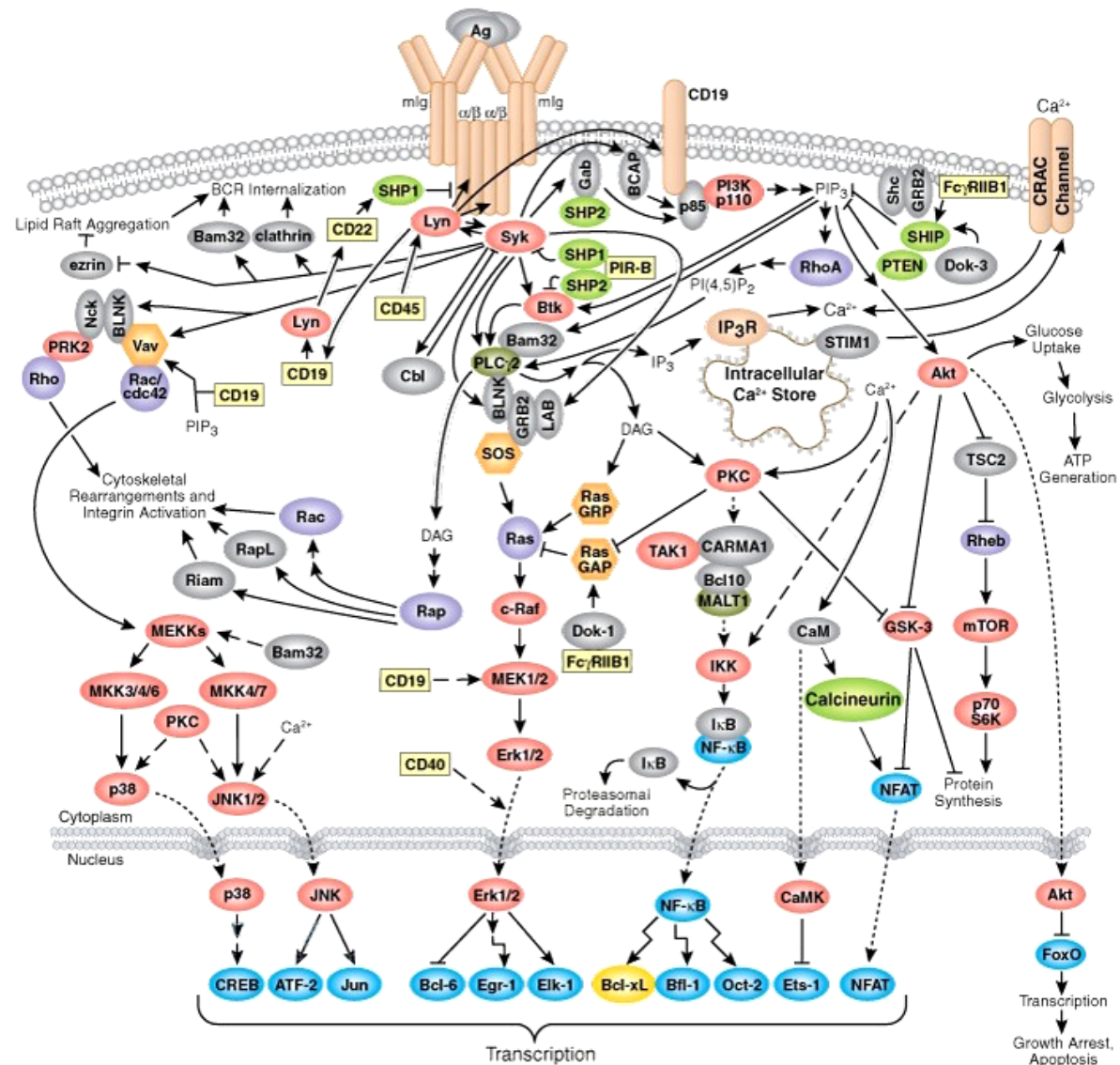
The shift in world view coincides with a **shift in our view of products.**

from

Hierarchical and closed

**See Eric Raymond's essay,
"The Cathedral and the Bazaar"**

to

Distributed and open

from
Complete edition

to
Continuous beta
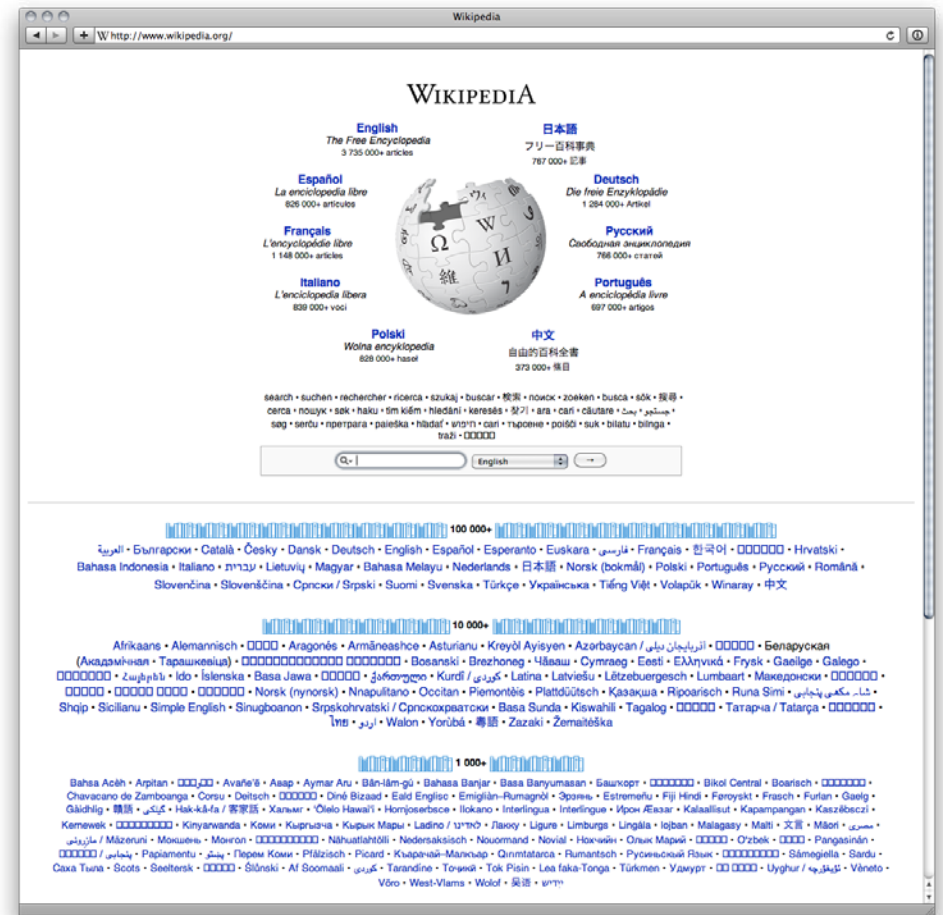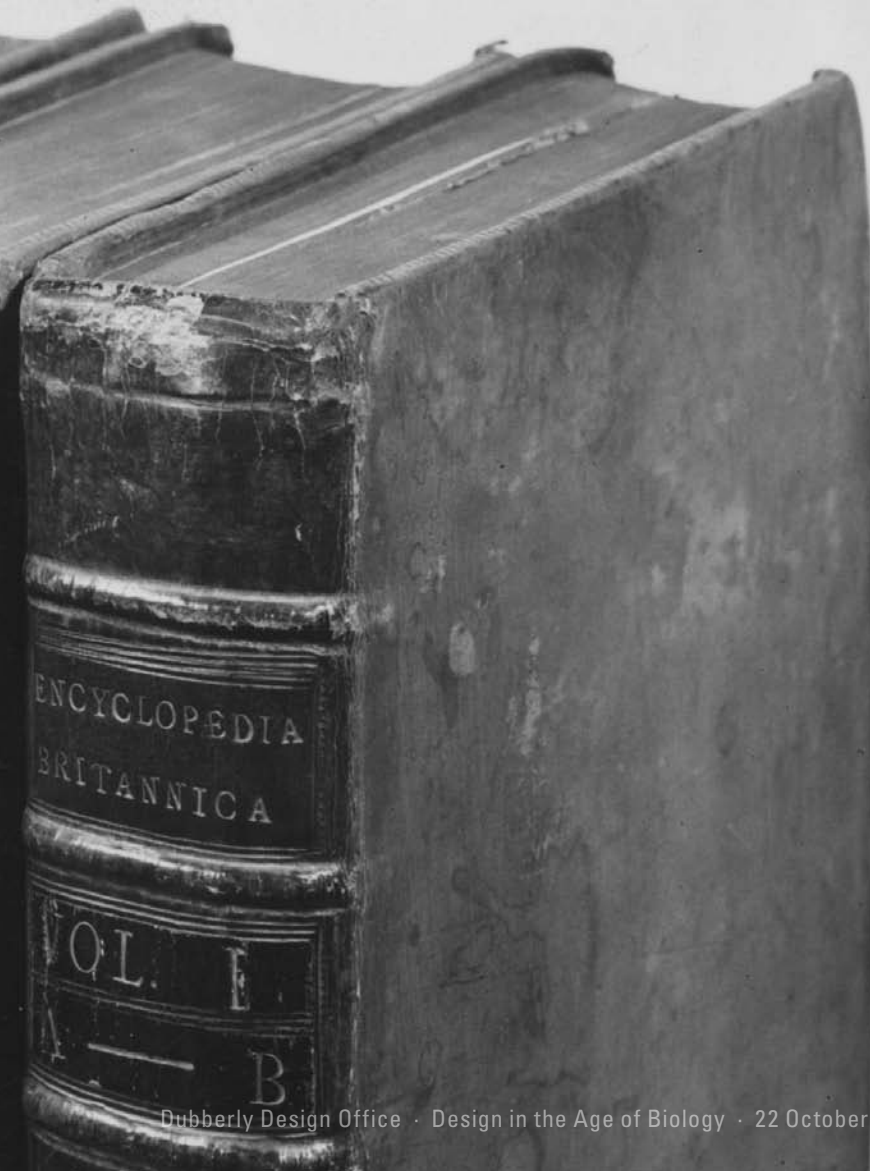
from
Objects

to
Experiences
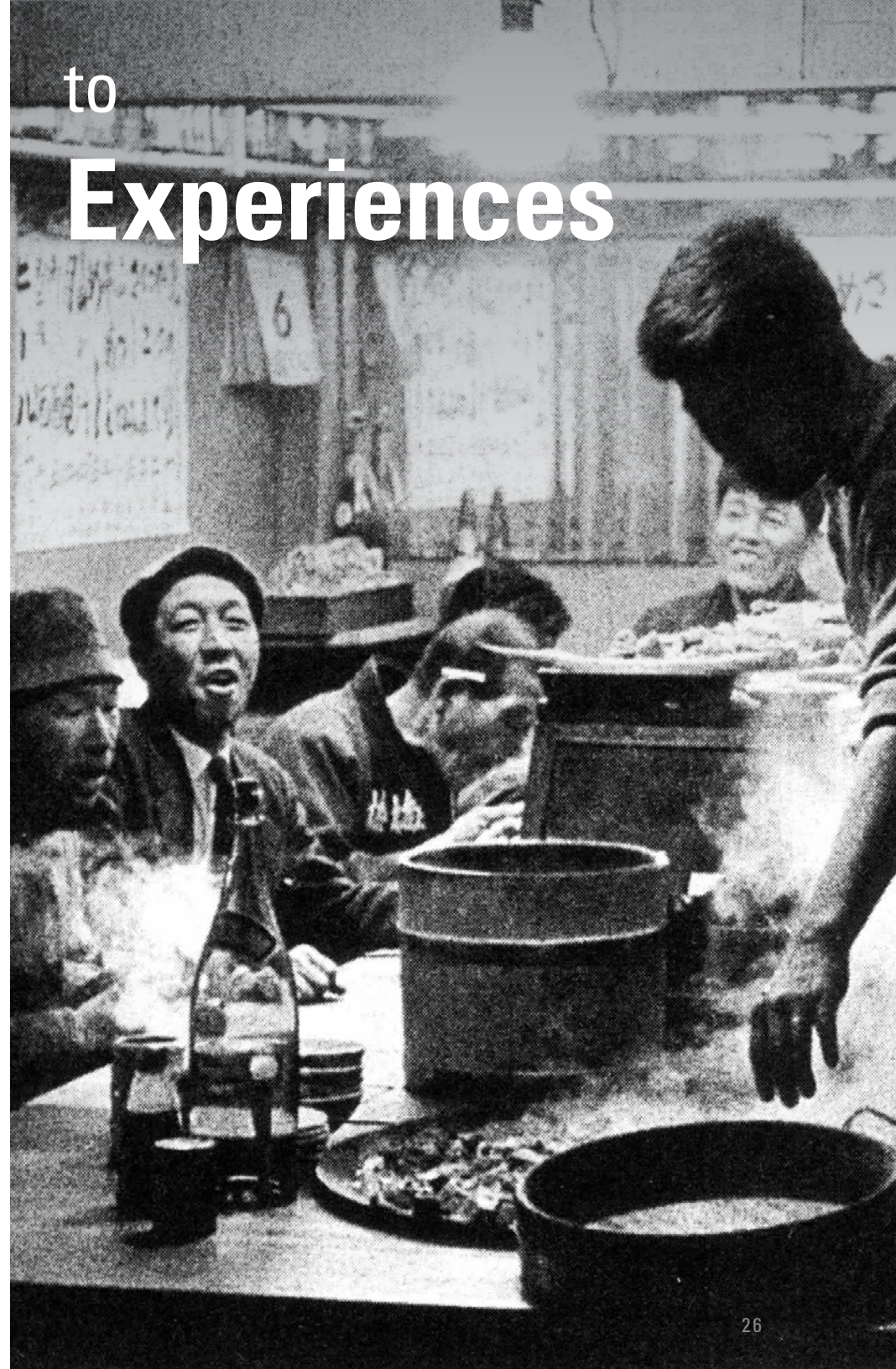
"... commercial products are best treated as though they were services.

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
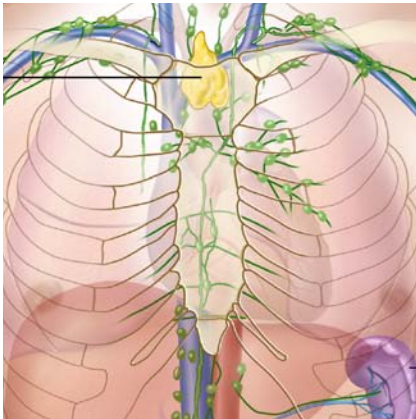
Immune System
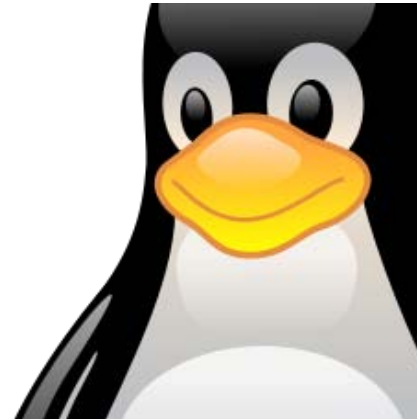
Linux Operating
System

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.

Components   **Tools**   **System**   **Experience**

Motor   Appliance   Kitchen   Cooking
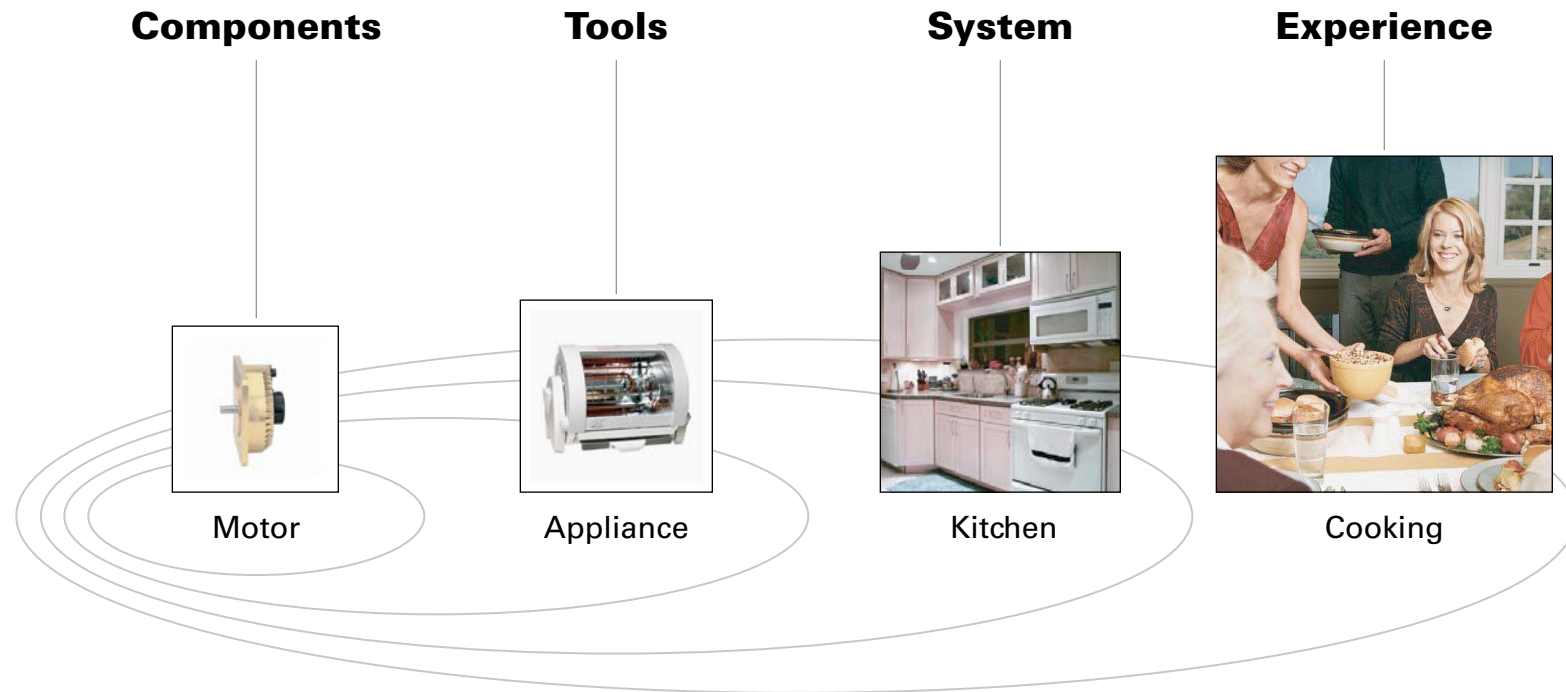
— John Rheinfrank & Fred Murrell

iPod is an **integrated system**.

DRAM > mp3 player > music sharing service > my music

Hardware **Software** **Networked Service** **Marketplace**

Music Listener   iPod   iTunes   iTunes Store   Record Companies   Artists
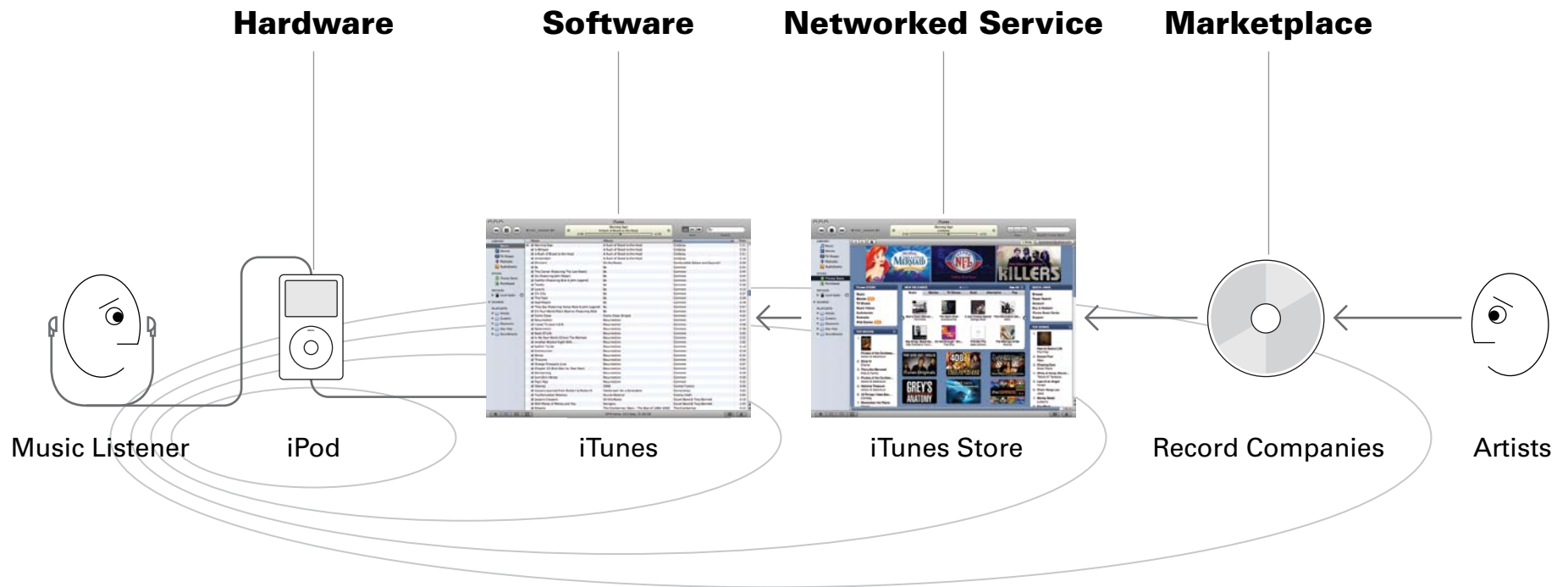
Smartphones are becoming hubs of body-area networks.

New/Additional sensors and actuators

Reinvent meter as health status tracker

Networked enabled services supported by subscription

Blood glucose

Blood pressure

Cholesterol

Heart rate

Hydration

Weight

Medication dosing and monitoring
e.g., insulin pump

Body Area Network Hub

Personal Computer

Connecting with caregivers
(e.g., Family, Physician)

Joining communities
for support and learning

Engaging with wellness coach
for behavior change

Amazon's Kindle-Reader-WisperNet-Store system is another networked-services ecology.

Hardware   **Software**   **Networked Service**   **Marketplace**

Reader   Kindle   Reader   Amazon Store   Publishers   Authors
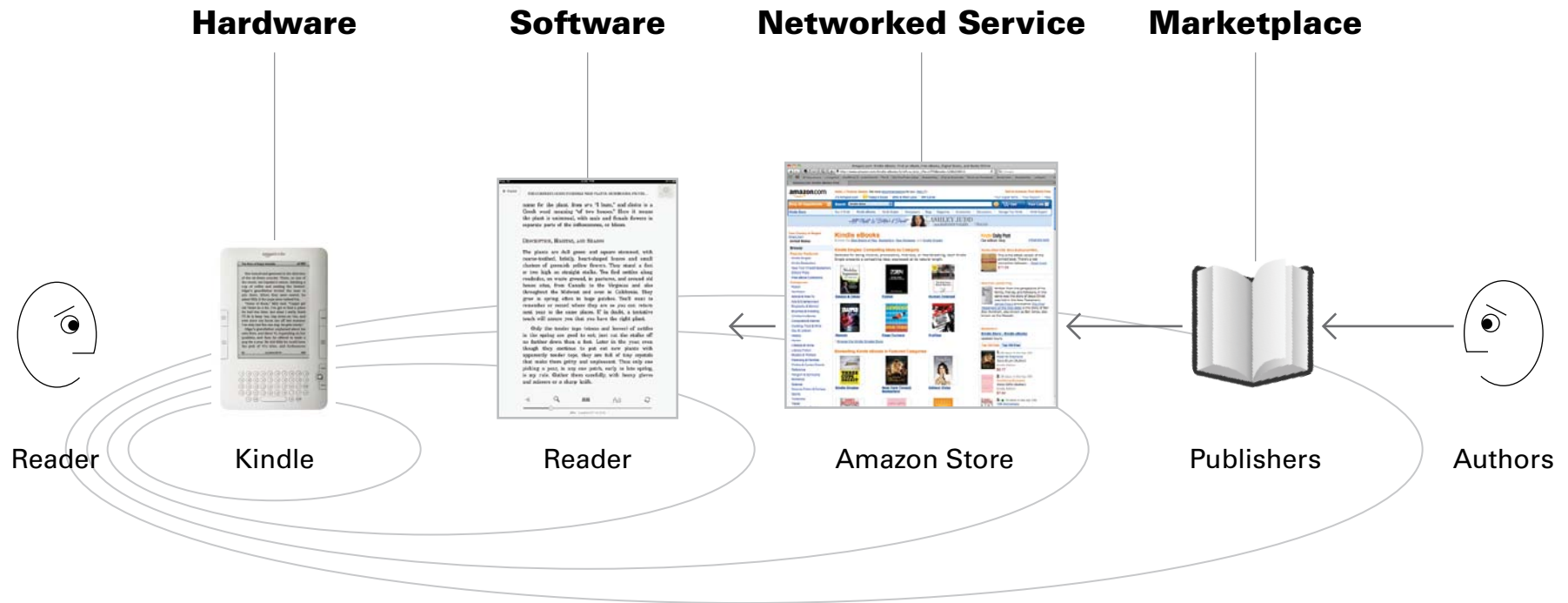
"I think of [the Kindle] as a service.
Part of [it] is of course the hardware,
but really, it's the software, the content,
it's the seamless integration of those things."
— Jeff Bezos

The shift
in the nature of products
requires a **shift**
in the way we **design.**

from
Expert/patient

to
'**Symmetry of ignorance**'

from
Author

to
Facilitator

from
Perfecting

to
Growing

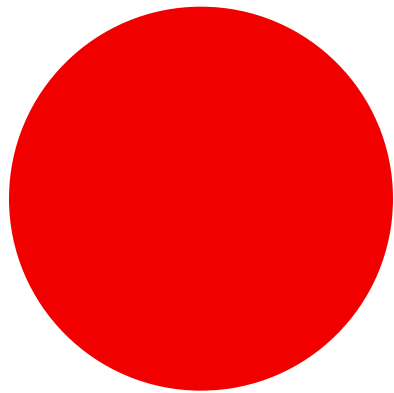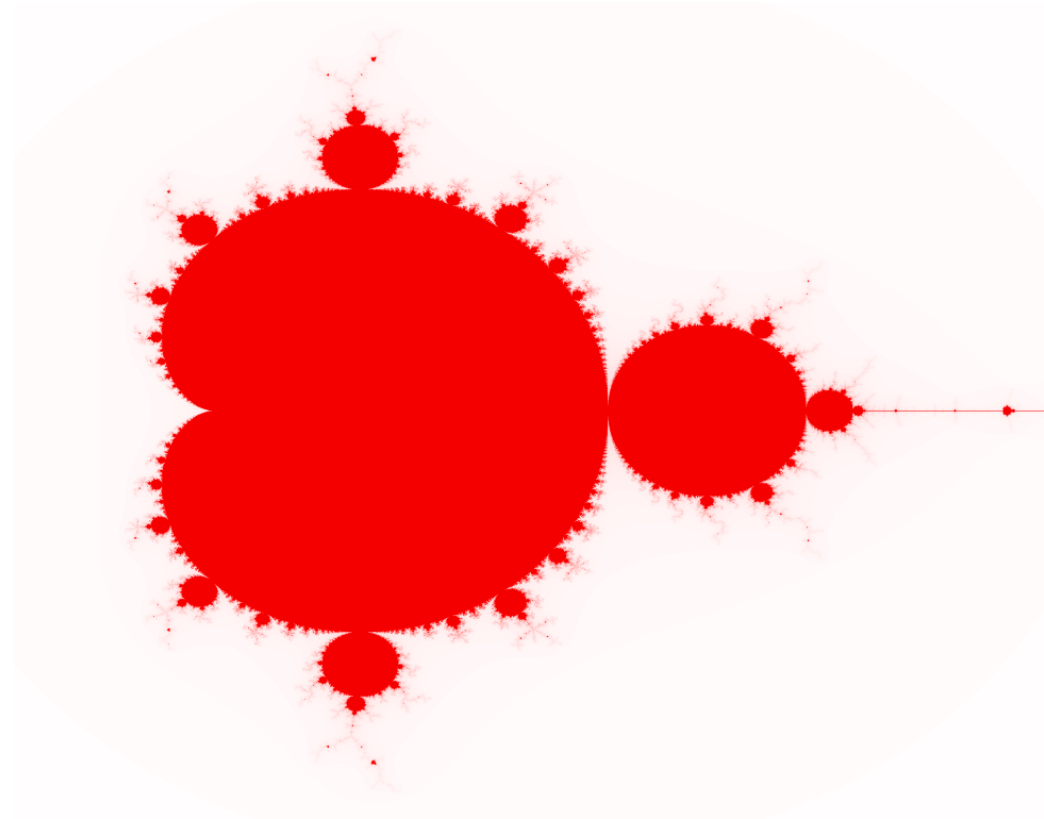|	From ... escaping the past **Manufacturing Age**	To ... inventing the future **Age of Biology**
Focus	**Objects/Things**	**Systems/Behaviors**
Values	**Seek simplicity**	**Embrace complexity**
Designer's role	**Expert/Deciding**	**Collaborator/Facilitating**
Construction	**Direct**	**Mediated**
Stopping condition	**Almost perfect**	**Good enough for now**
Result	**More deterministic**	**Less predictable**
End state	**Completed**	**Adapting continuously**

What does this mean?

Nodes—Nouns—Objects.
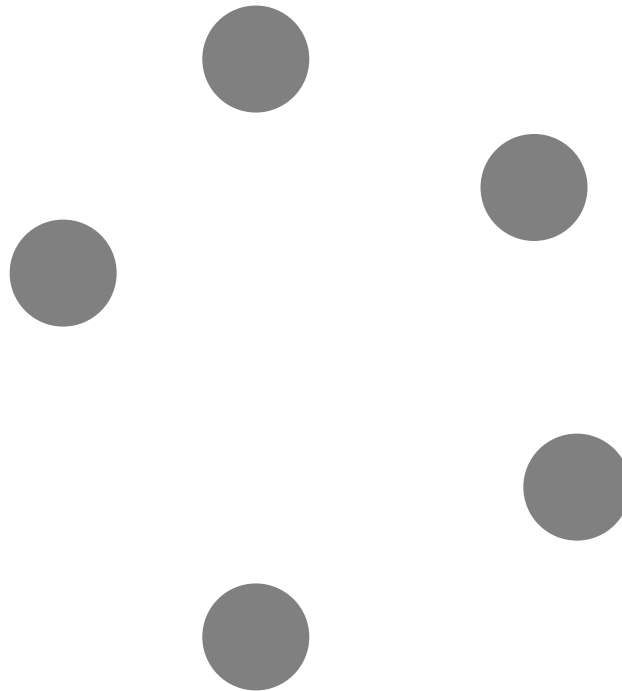
Links—Verbs—Systems.

Hydrologic Cycle.

Rain Clouds

Precipitation

Cloud Formation

Evaporation + Condensation

Snow

Lake

Ocean

Ground

Cradle to Cradle.

Product
Creation and Packaging

Materials Processing
Energy used to process raw materials

Distribution
Delivery of product to marketplace

Replenishment
What it takes to grow back what was used

Raw Materials
Basic elements used to create product

Consumption and Use
Sold in marketplace

Disassembly/ Reprocessing
Energy used to revert into raw materials

Disposal
End of product life cycle

Collection
Take-back Program, Recycling, Re-Use, Sold as "used" in Marketplace

—McDonough and Braungart

Thinking in terms of **whole systems** means
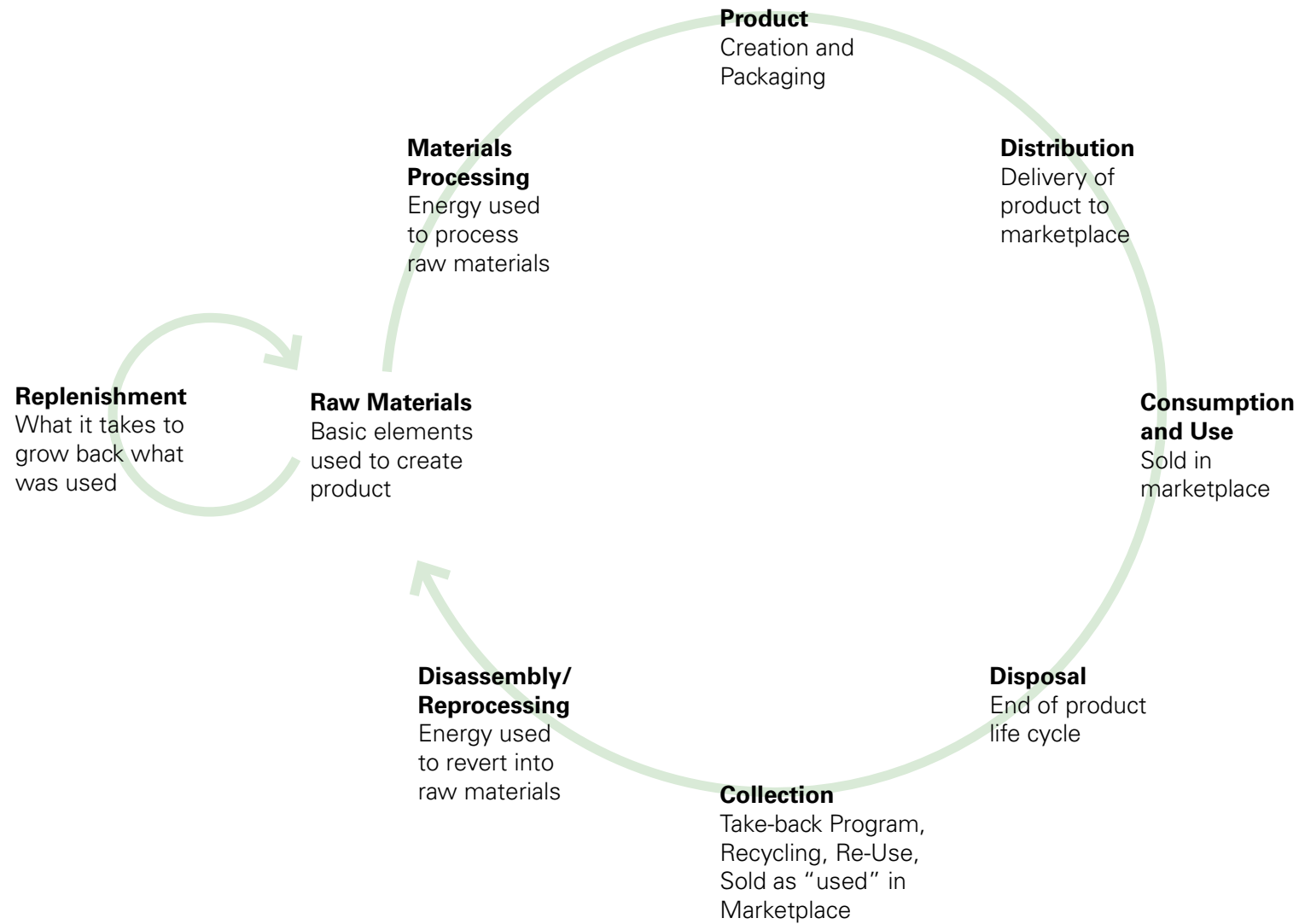
- Building **relationships** between products
  e.g. roadmaps, product lines, platforms, APIs

- **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.

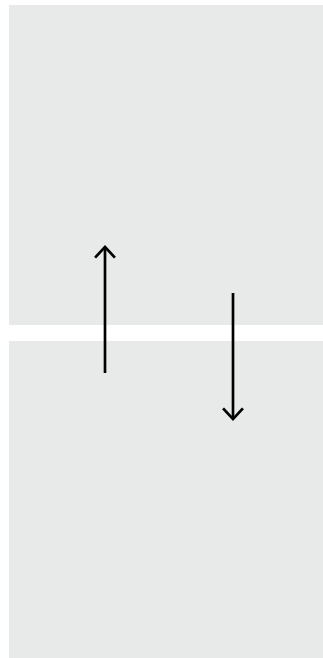**How** are we making it?
Form/Grammar
Syntactic
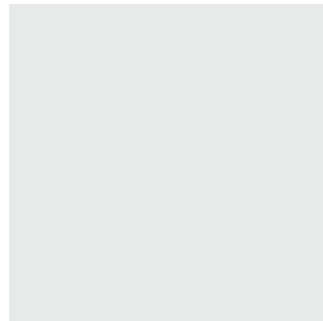
Object
Component

Form is governed by meaning and structure, though they are also affected by form.

What are we making?
Meaning/Definition
Semantic

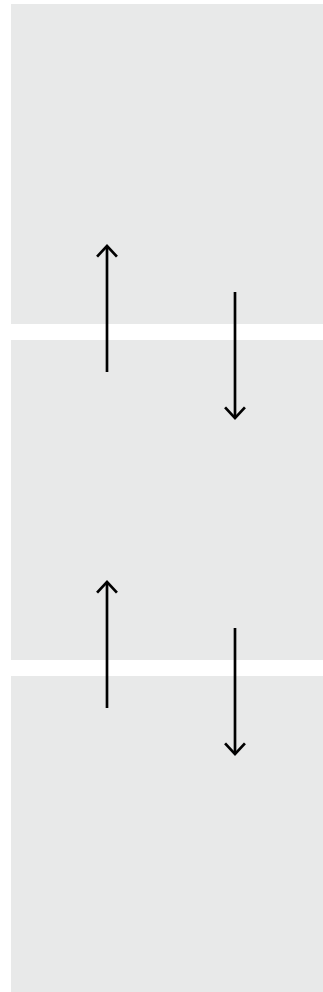**How** are we making it?
Form/Grammar
Syntactic

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
Semantic

How are we making it?
Form/Grammar
Syntactic

Object
Component

System
Systems of components
Organism

Systems are often embedded in ecologies— communities of systems.

Why are we making this?
Context/Need
Pragmatic

What are we making?
Meaning/Definition
Semantic
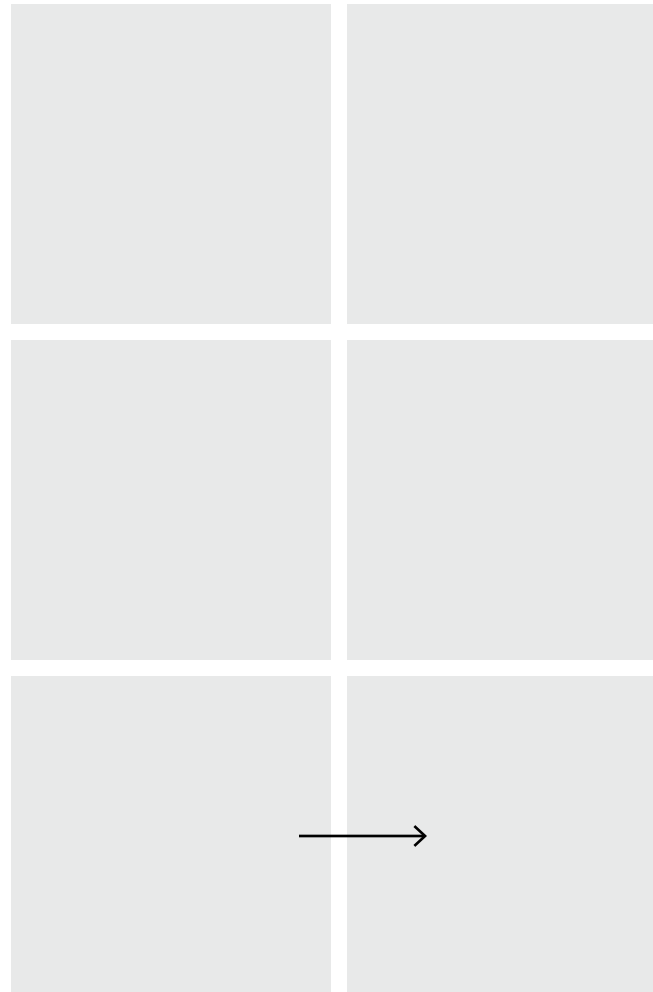
How are we making it?
Form/Grammar
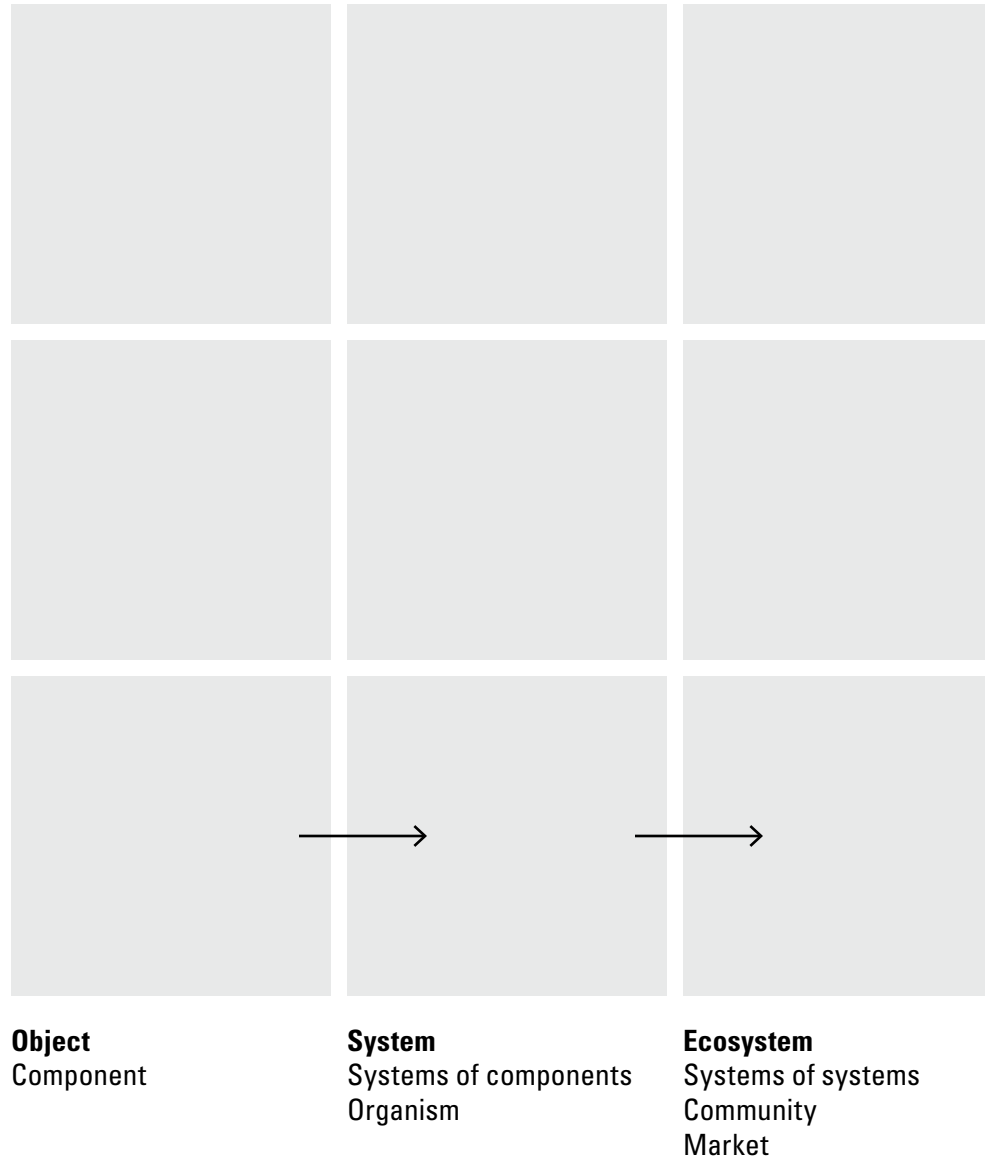Syntactic

Object
Component

System
Systems of components
Organism

Ecosystem
Systems of systems
Community
Market

Practice focused on the form of objects can be direct and unmediated.

Why are we making this?
Context/Need
Pragmatic

What are we making?
Meaning/Definition
Semantic

How are we making it?
Form/Grammar
Syntactic

Individual
Intuitive
Idiosyncratic

Object
Component

System
Systems of components
Organism

Ecosystem
Systems of systems
Community
Market

As practice expands, it becomes more complex.

Why are we making this?
Context/Need
Pragmatic

What are we making?
Meaning/Definition
Semantic
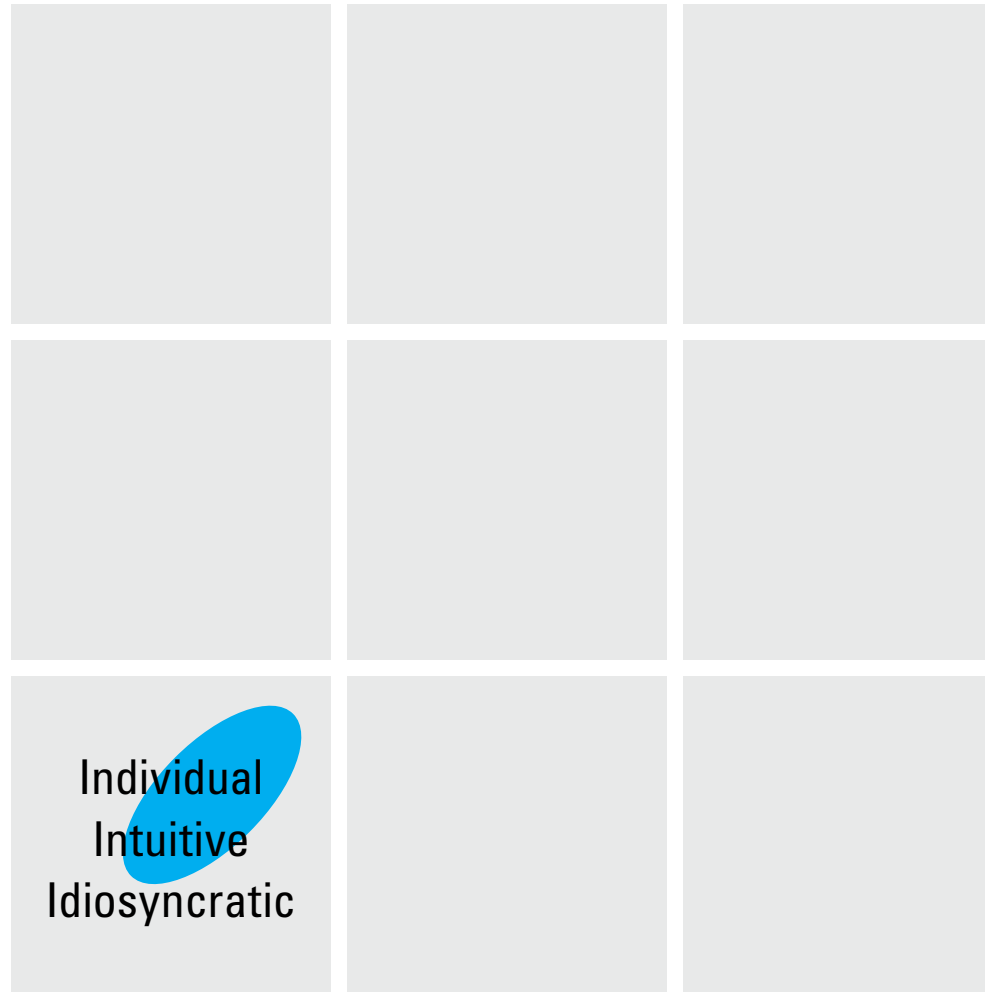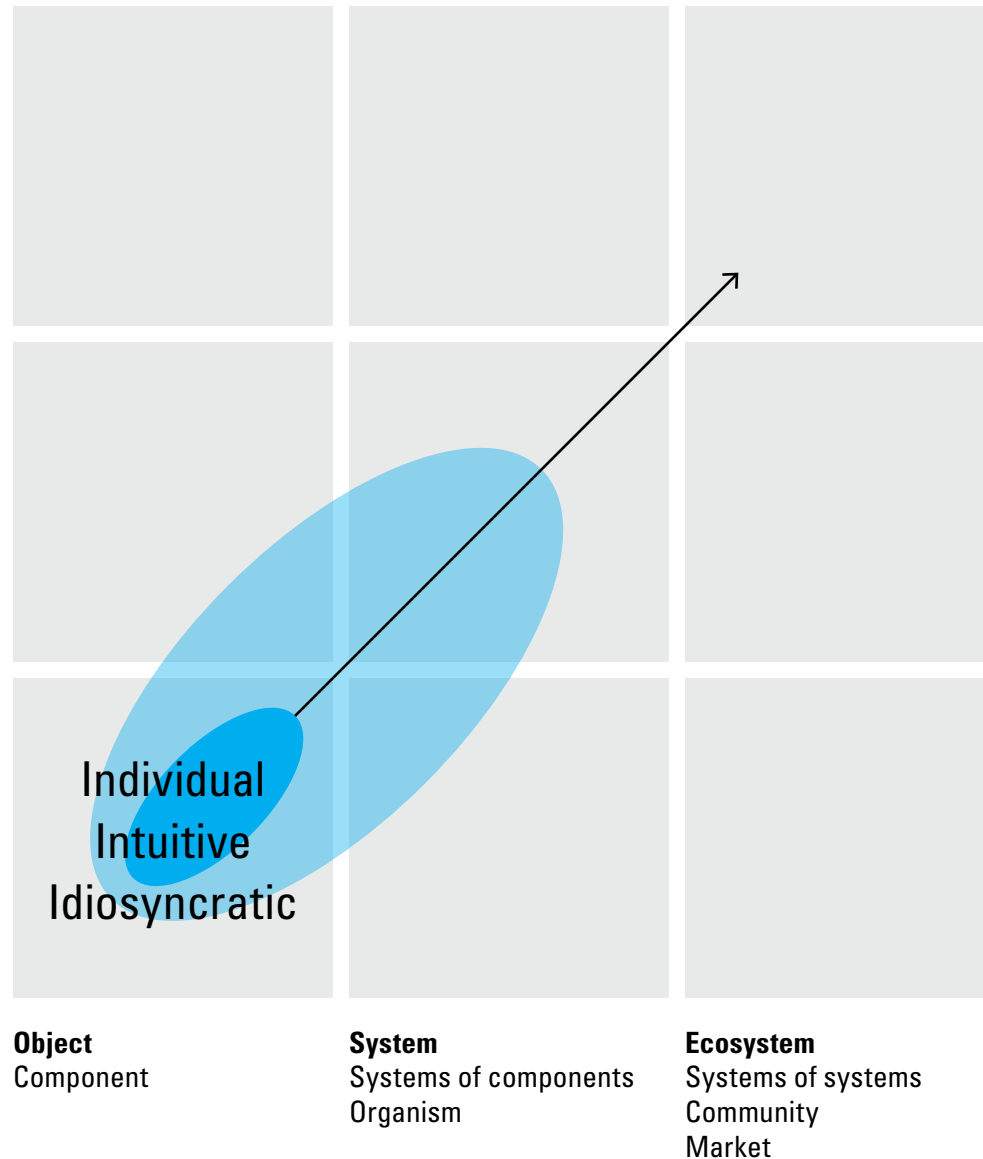
How are we making it?
Form/Grammar
Syntactic

Individual
Intuitive
Idiosyncratic

Object
Component

System
Systems of components
Organism

Ecosystem
Systems of systems
Community
Market

When practice also concerns context + ecologies, project teams require many disciplines.

Why are we making this?
Context/Need
Pragmatic

What are we making?
Meaning/Definition
Semantic

How are we making it?
Form/Grammar
Syntactic

Team
Explicit
Shared

Individual
Intuitive
Idiosyncratic

Object
Component

System
Systems of components
Organism

Ecosystem
Systems of systems
Community
Market

Moving our focus from the form of objects to the behavior of systems requires research.

Why are we making this?
Context/Need
Pragmatic

What are we making?
Meaning/Definition
Semantic

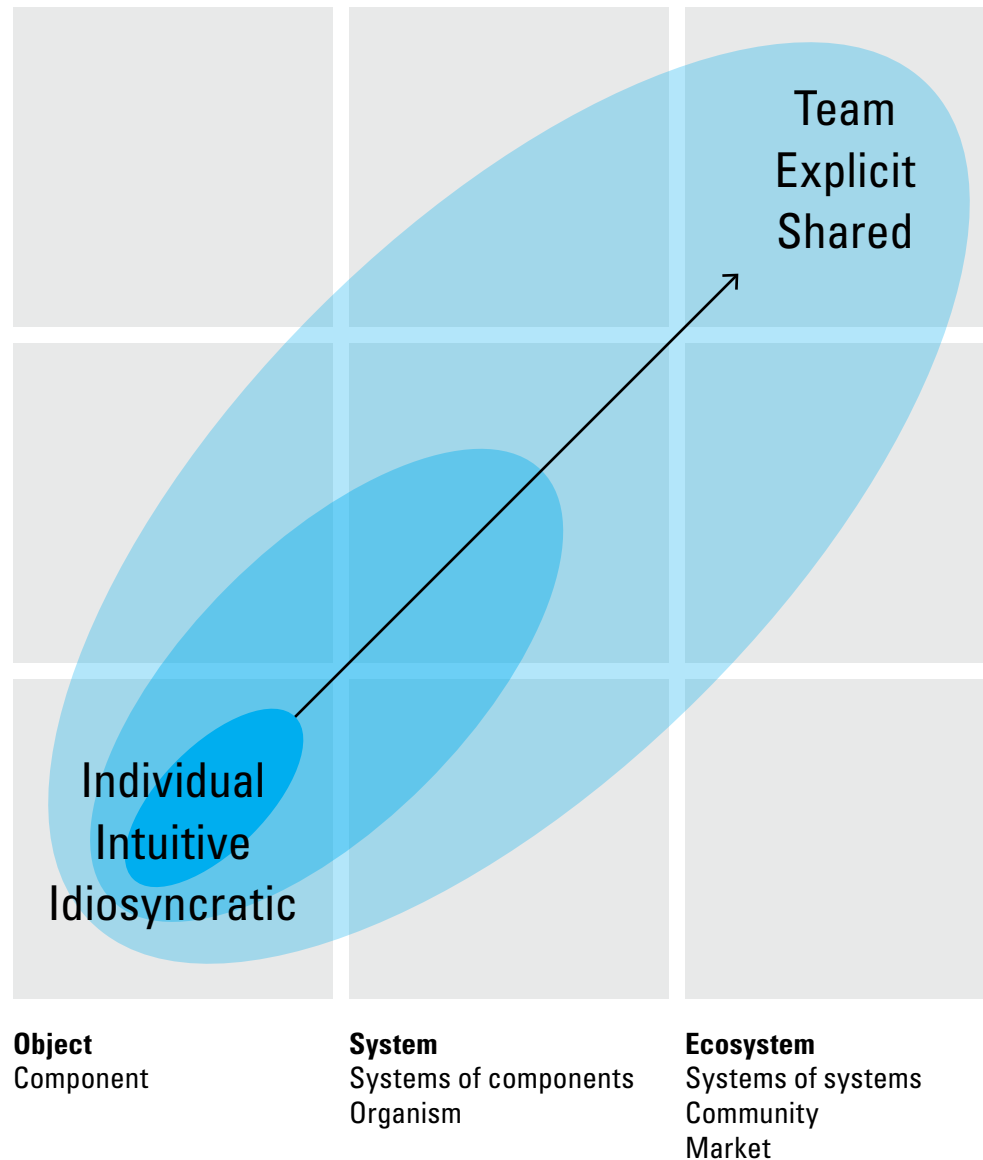**How** are we making it?
Form/Grammar
Syntactic

RESEARCH

Object
Component

System
Systems of components
Organism

Ecosystem
Systems of systems
Community
Market

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

Twenty-first century design practice already focuses largely on the behavior of systems.
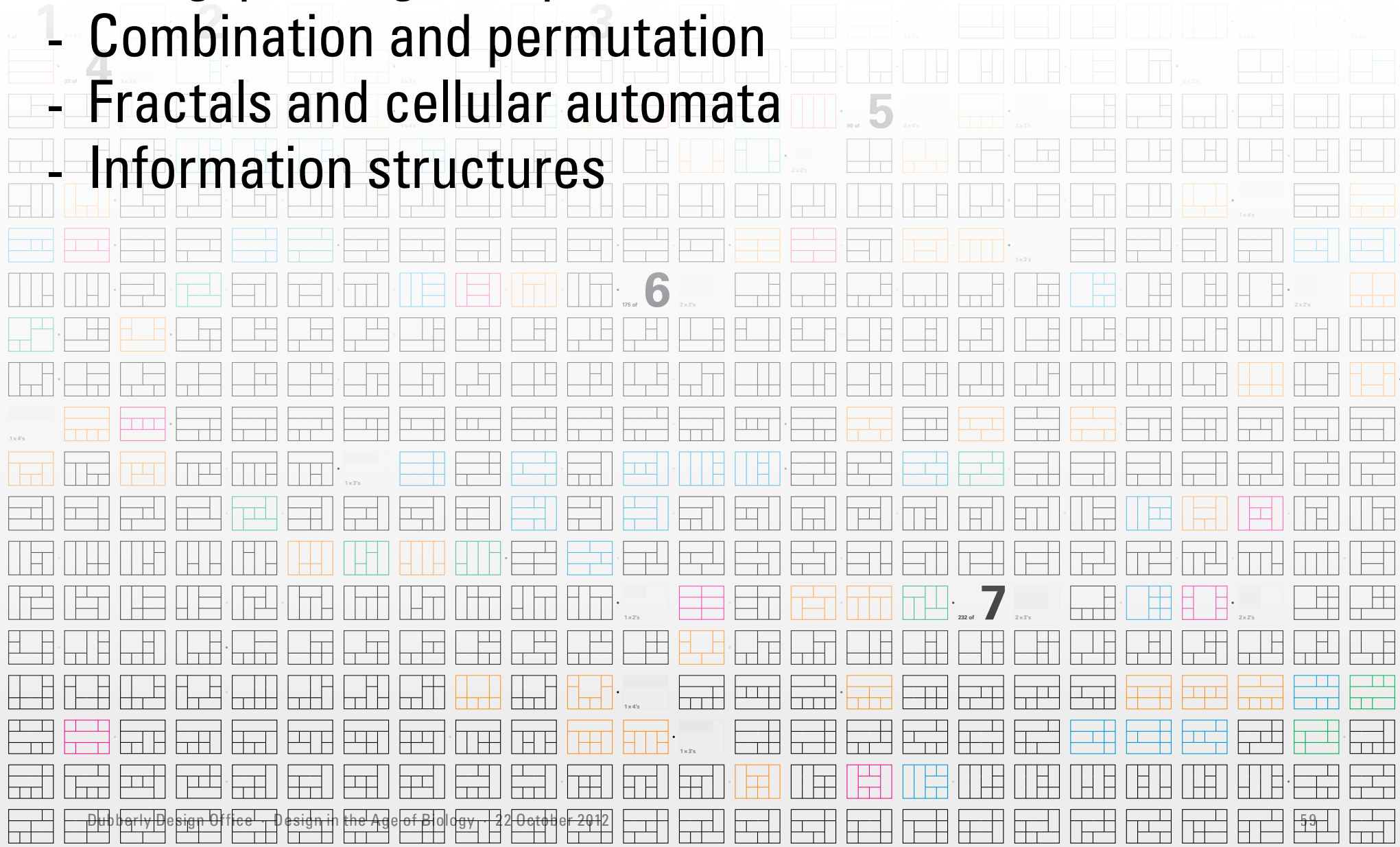
Let's (re-) imagine design education from a system's perspective.

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
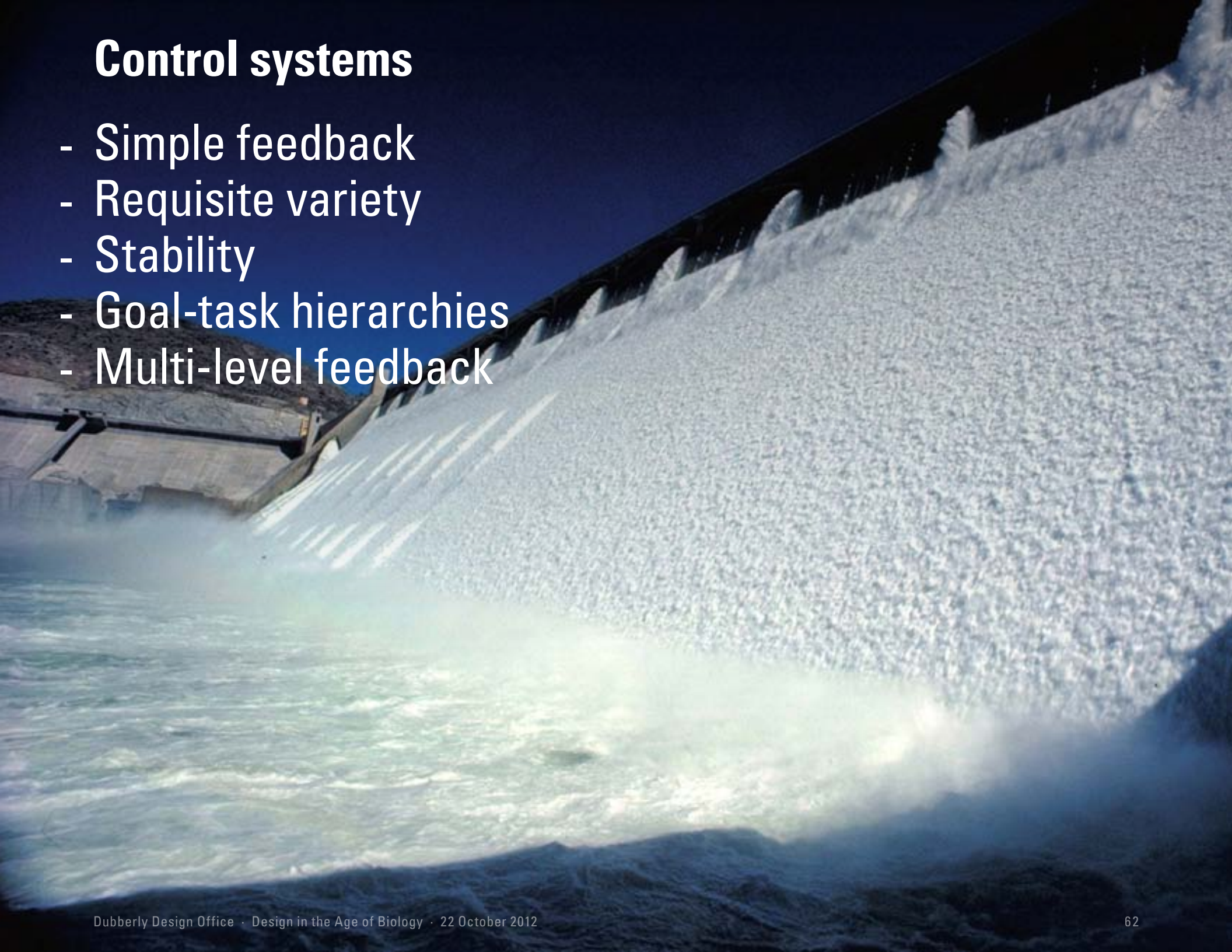- Matching systems
- Voting systems

Dynamic systems

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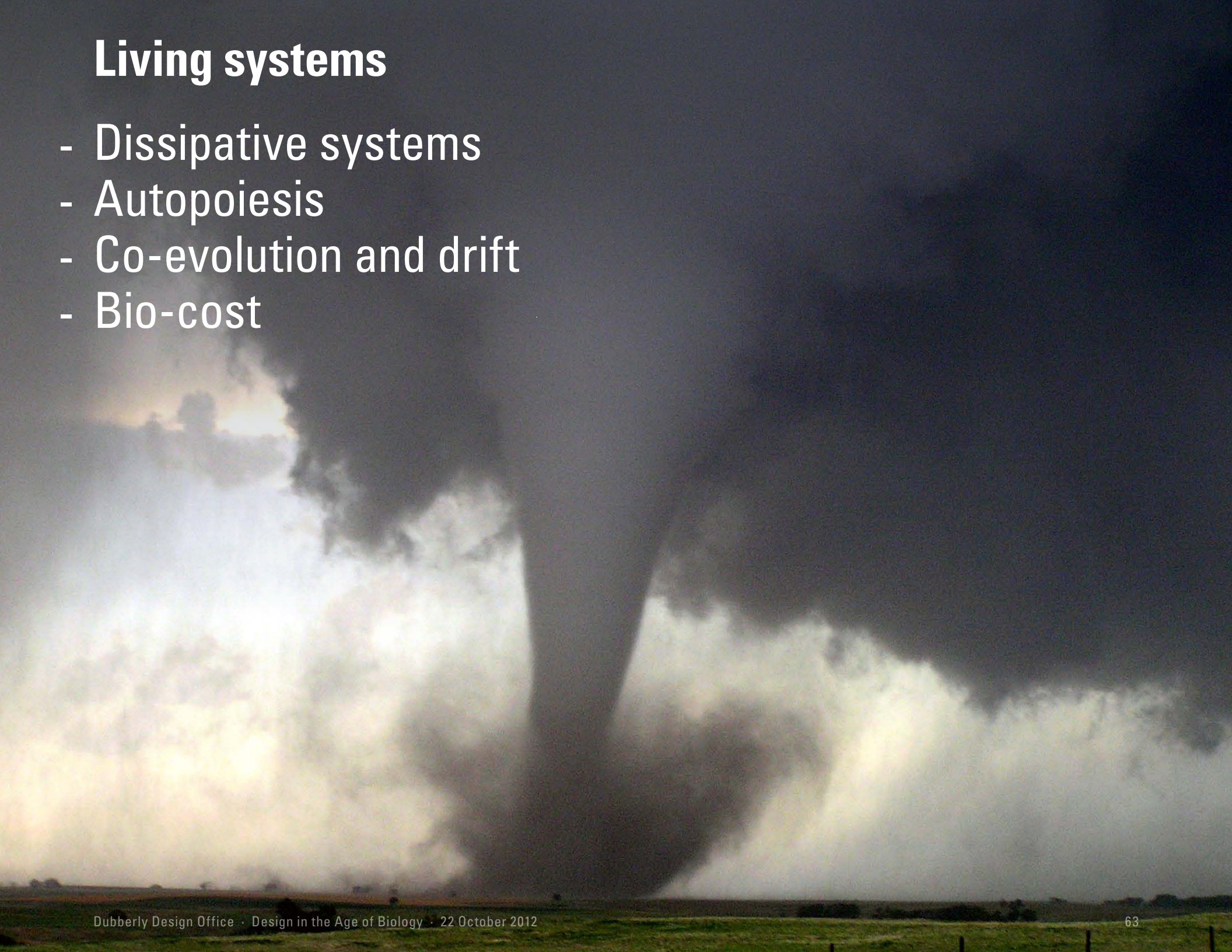- Dynamic equilibrium and homeostasis

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
Michael Gallagher

hugh@dubberly.com
415 648 9799

Presentation posted at
www.dubberly.com/presentations/ocac_design_biology.pdf