Mitigation and Adaptation Studies

Class 5: Systems Science and Systems Thinking

Contents:

Sustainability Leadership - Five important competencies (From Class 467)

1. Systems thinking: Connected, holistic thinking. Understanding the context behind a problem and its relationship to trends in broader environments. For example, a sustainability leader grasps the system of relationships in which the system under consideration is embedded: Flows in and out, surrounding and interconnected systems, interactions between human and non-human systems. Requires multidisciplinary backgrounds combining technical and creative fields. Expertise and knowledge in principles of systems management such as resilience and managing for emergence.

2. External collaboration: Work with entities beyond the own organization. Significant environmental impact may be found in collaboration. Collaboration helps organizations build social capital, explore new opportunities and shape the contexts in which they operate. Investing in partnerships between governmental organizations, NGOs and businesses.

3. Social innovation: The magnitude of sustainability challenges demands a fundamental reengineering of societal processes. Leaders with social innovation competence view this challenge as a growth opportunity. Social innovators find ways to redesign processes that create social value. They question the status quo and treat constraints as transformable. Within organizations, innovative leaders encourage social entrepreneurship among employees and prioritize interdisciplinary teams.

4. Sustainability literacy: Sustainability-literate leaders are aware of emerging environmental and social trends, and the risks and opportunities they create for society. Fundamentally, they understand the changing roles of sectors, organizations and groups in society. They see the need for conducting environmental and social cost accounting, or using tools for scenario planning, back-casting, and hot spot analyses.

5. Active values: A leader with active values is mindful of emotions and motivations and sensitive to those of others. Mindful leaders can view themselves and their work as part of a larger purpose, motivating them to harness organizations to improve society.

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Sustainability Leadership Case Studies (From Class 467)

REGIONAL SEA LEVEL RISE, CLIMATE CHANGE, AND SPECIES ADAPTATION SCENARIOS FOR FLORIDA

Norfolk, Virginia
June 2017

OLD DOMINION UNIVERSITY

Building Conservation Leaders

CLIMATE CHANGE, SEA LEVEL RISE, AND THE HUMAN IMPACTS ON THE AMERICAN CROCODILE IN THE EVERGLADES NATIONAL PARK

Department of Biological Sciences
Old Dominion University
Norfolk, Virginia

Case Studies: 1 Identify the system and its environment
2 Specify the problem

- Landfills and Sea Level Rise
- Limiting Energy Usage
- Preparing the Economy for Climate Change and Sea Level Rise
- Tourism and Sea Level Rise
- Extinction of Species
- Extinction and Food Security
- Pollution
- Invasive species
- Chesapeake Bay under climate change and sea level rise
- Industrial waste and sea level rise
- Food-Water-Energy Nexus
- Degradation of Mangroves
- Loss of Ecosystem Services of Wetlands
- Ocean Acidification/Warming and Coral Reefs
- Sustainable Cities
- Soil Degradation and Sustainable Farming
- Urban Agriculture
- Wildfires
- Climate Change and Agriculture
- Population growth and sustainability
- Impacts of sea level rise and climate change on the Back Bay National Wildlife Refuge
- Sargassum
- Plastic Pollution in the Ocean
- Lionfish

Systems Science

SYSTEMS and BEHAVIORAL RESEARCH SCIENCE

Research Paper | Open Access

Understanding Systems Science: A Visual and Integrative Approach

Andreas Hieronymi

First published: 18 October 2013 | https://doi.org/10.1002/sres.2215 | Cited by: 10

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Abstract

Systems thinking is considered a much-needed competence to deal better with an increasingly interlinked and complex world. The many streams within systems science have diversified perspectives, theories and methods, but have also complicated the field as a whole. This makes it difficult to understand and master the field. Short introductions to fundamental questions of systems science are rare. This paper is divided into three parts and aims to do the following: (1) to provide a broad overview of the structure and purpose of systems science; (2) to present a set of key systems principles and relate them to theoretical streams; and (3) to describe aspects of systems-oriented methodologies within a general process cycle. Integrative visualizations have been included to highlight the relationships between concepts, perspectives and systems thinkers. Several new attempts have been made to define and organize system concepts and streams in order to provide greater overall coherence and easier understanding.

SYSTEMS and BEHAVIORAL RESEARCH SCIENCE

Research Paper

Rethinking Systems Thinking: Learning and Coevolving with the World

David Ing

First published: 10 October 2013 | https://doi.org/10.1002/sres.2229 | Cited by: 3

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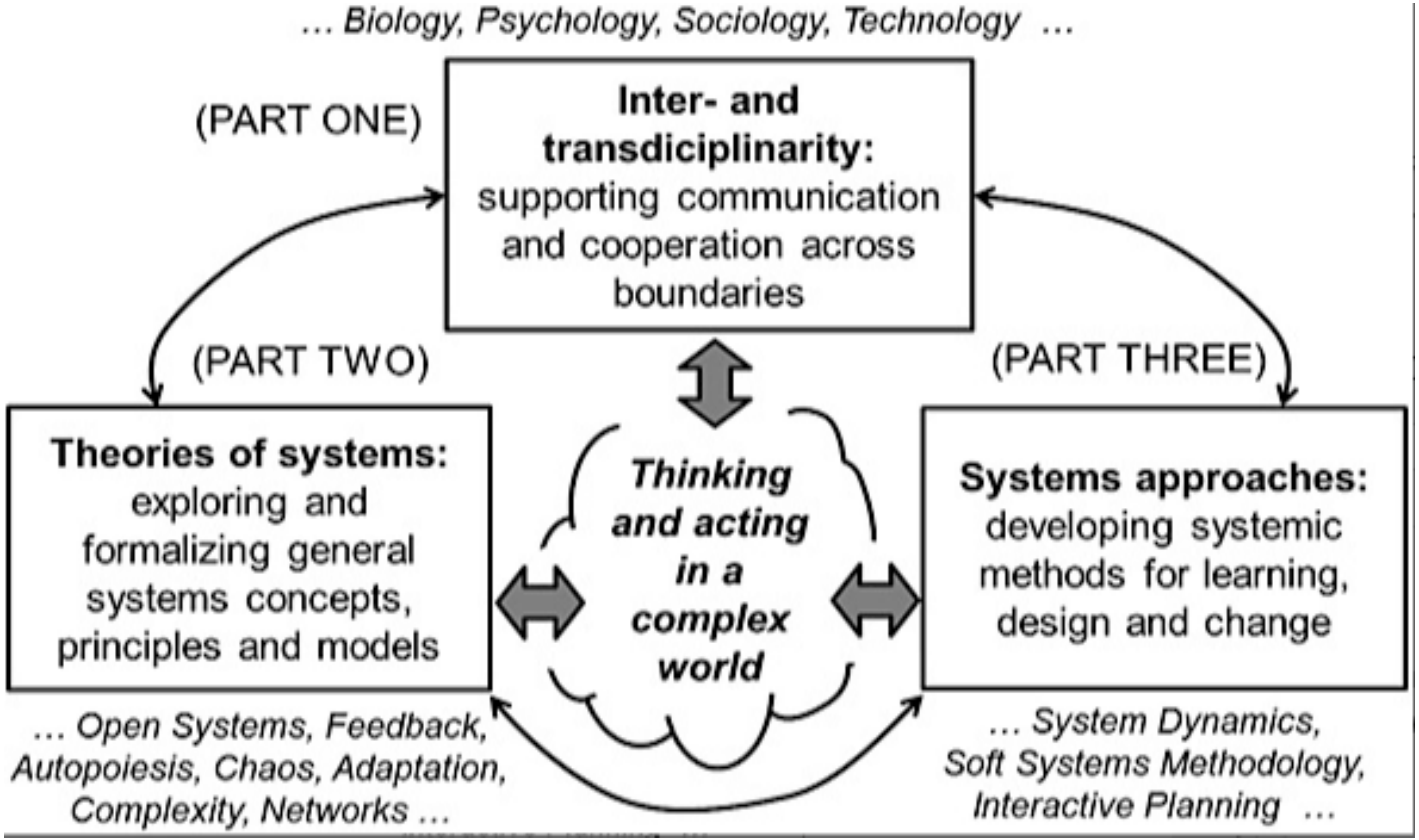
Abstract

Much of systems thinking, as commonly espoused today, was developed by a generation in the context of the 1950s–1980s. In the 2010s, has systems thinking changed with the world in which it is to be applied? Is systems thinking *learning* and *coevolving* with the world? Some contemporary systems thinkers continue to push the frontiers of theory, methods and practice. Others situationally increment the traditions of their preferred gurus, where approaches proven successful in prior experiences are replicated for new circumstances. Founded on interactions with a variety of systems communities over the past 15years, three ways to rethink systems thinking are proposed:

1. 'parts and wholes' snapshots → 'learning and coevolving' over time
2. social and ecological → emerged environments of the service economy and the Anthropocene
3. episteme and techne → phronesis for the living and nonliving

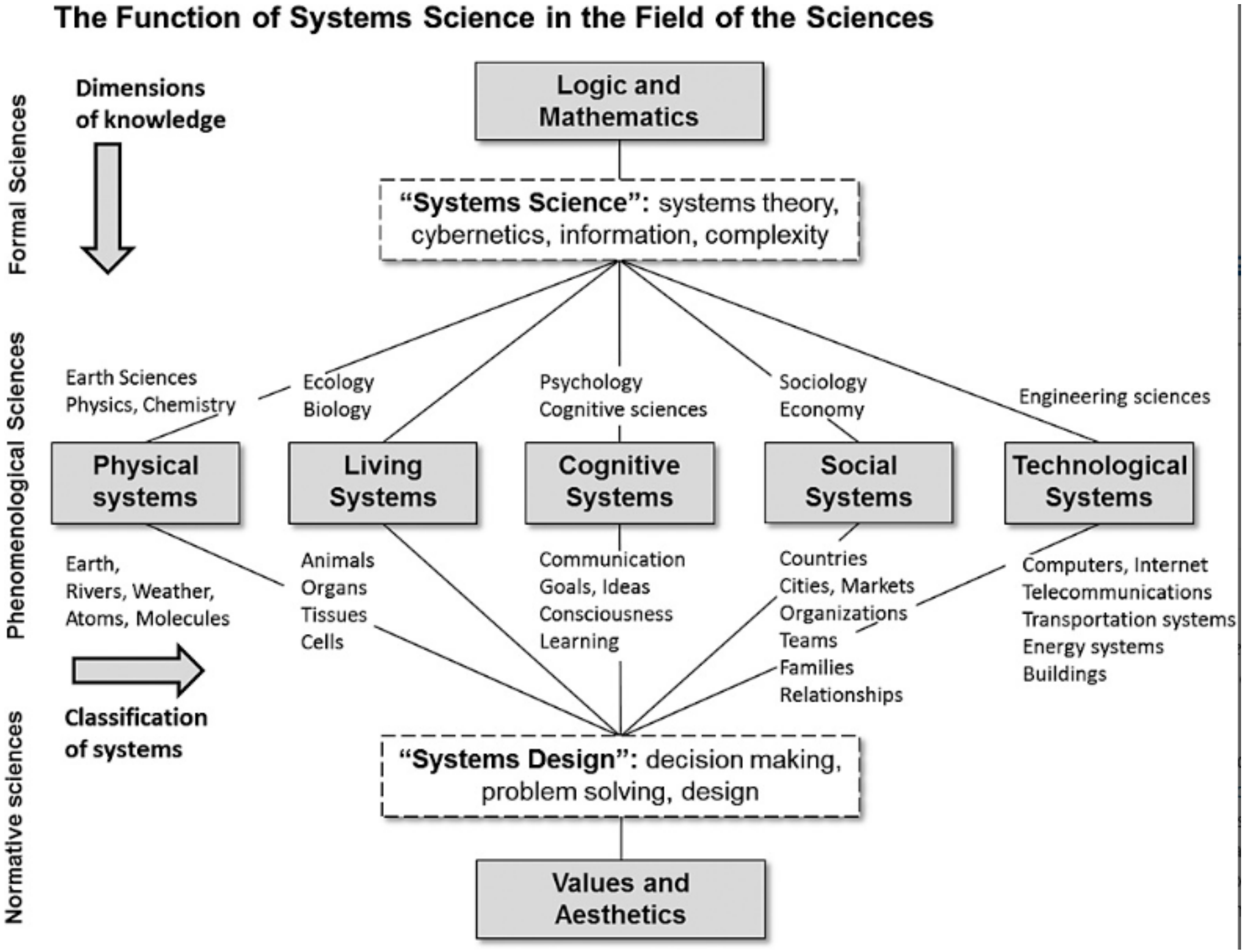
These proposed ways are neither exhaustive nor sufficient. The degree to which systems thinking should be rethought may itself be controversial. If, however, systems thinking is to be authentic, the changed world of the 21st century should lead systems thinkers to engage in a reflective inquiry.



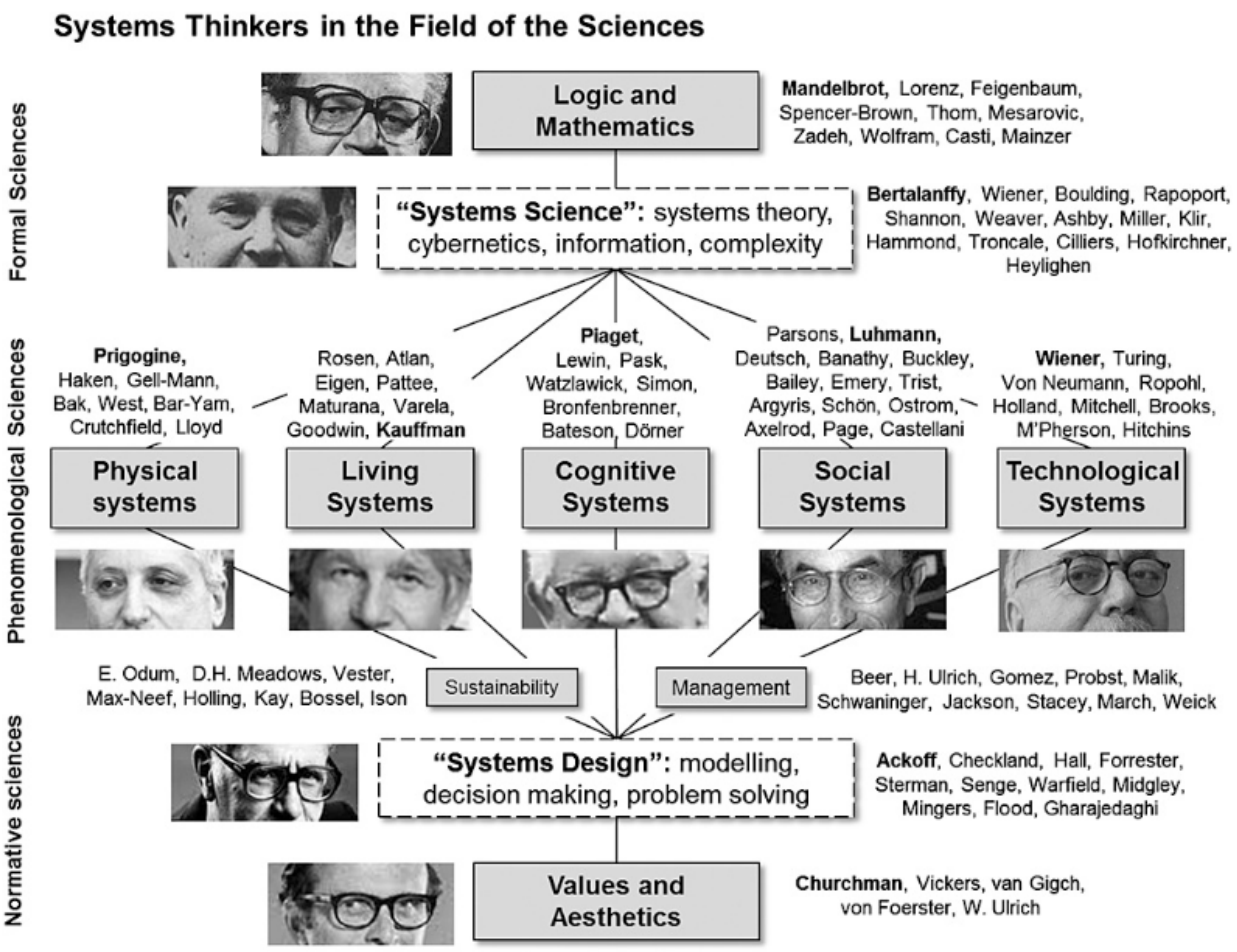
Three faces of systems science

Hieronymi, 2013

Systems Science

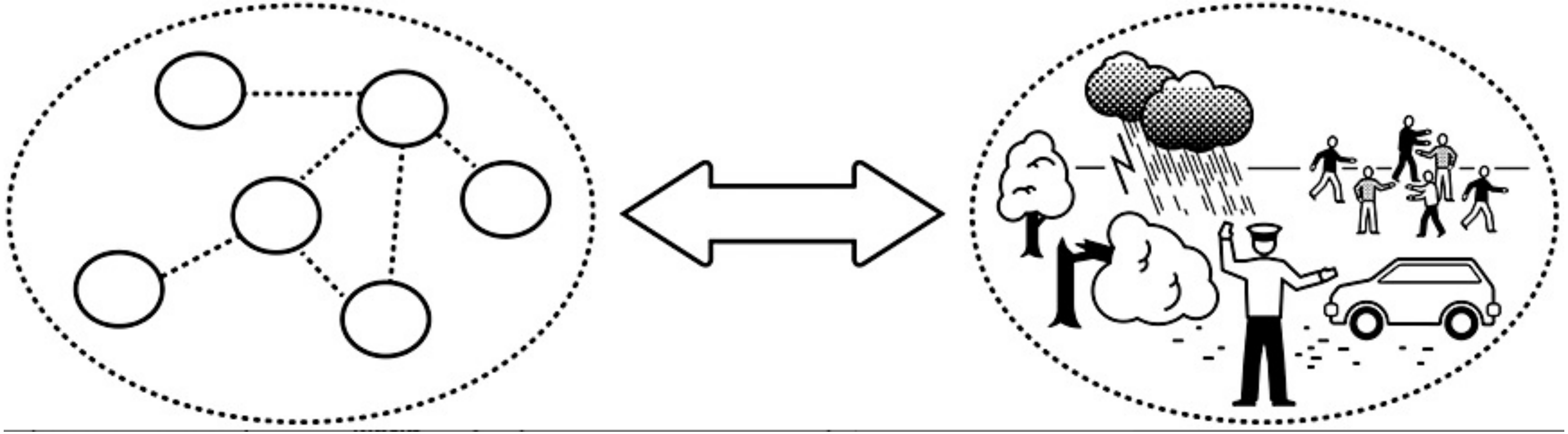


Map of science—with a special focus on systems science and systems design *Hieronymi, 2013*



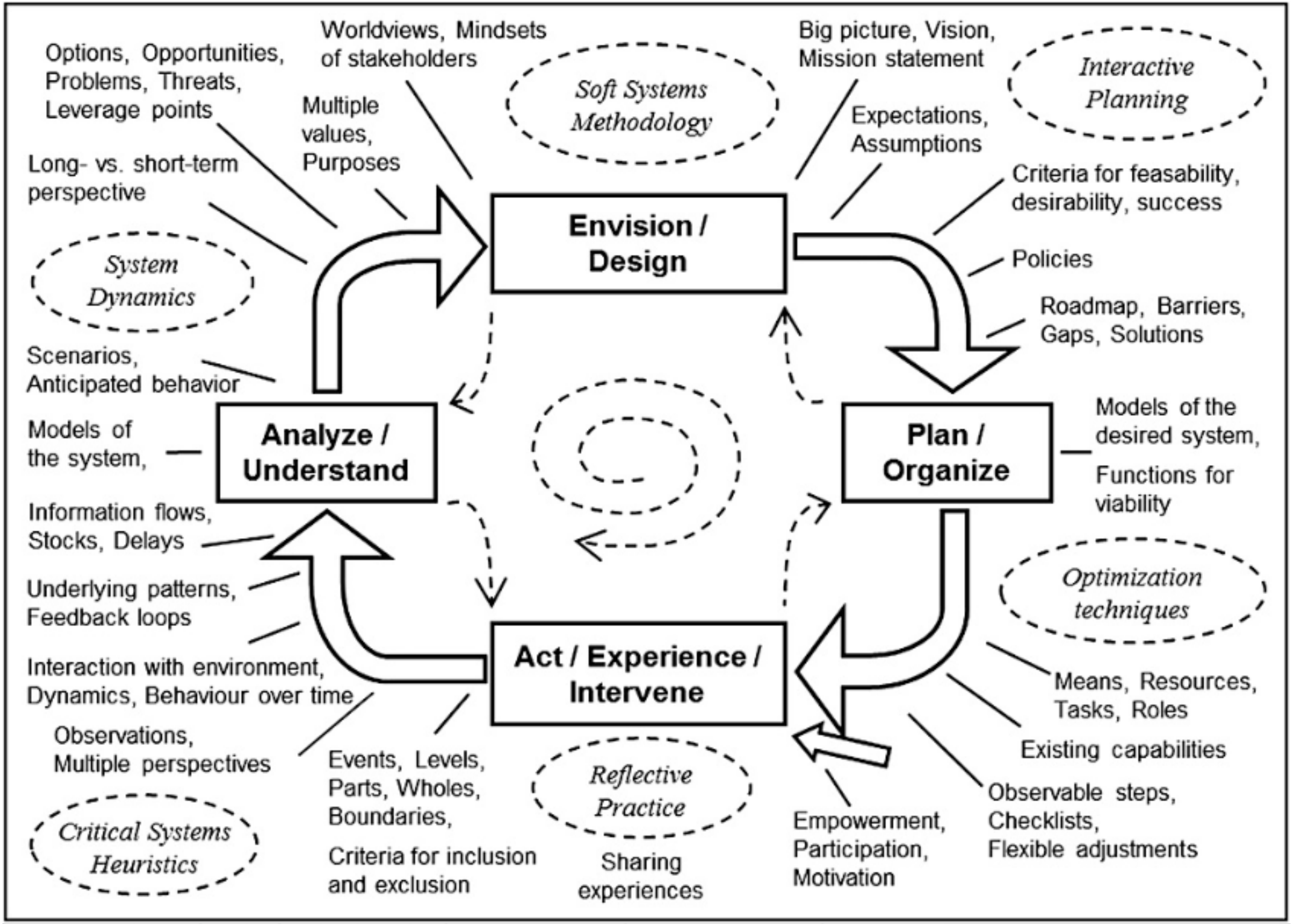
Overview of systems thinkers and their position in the field of the sciences

Hieronymi, 2013



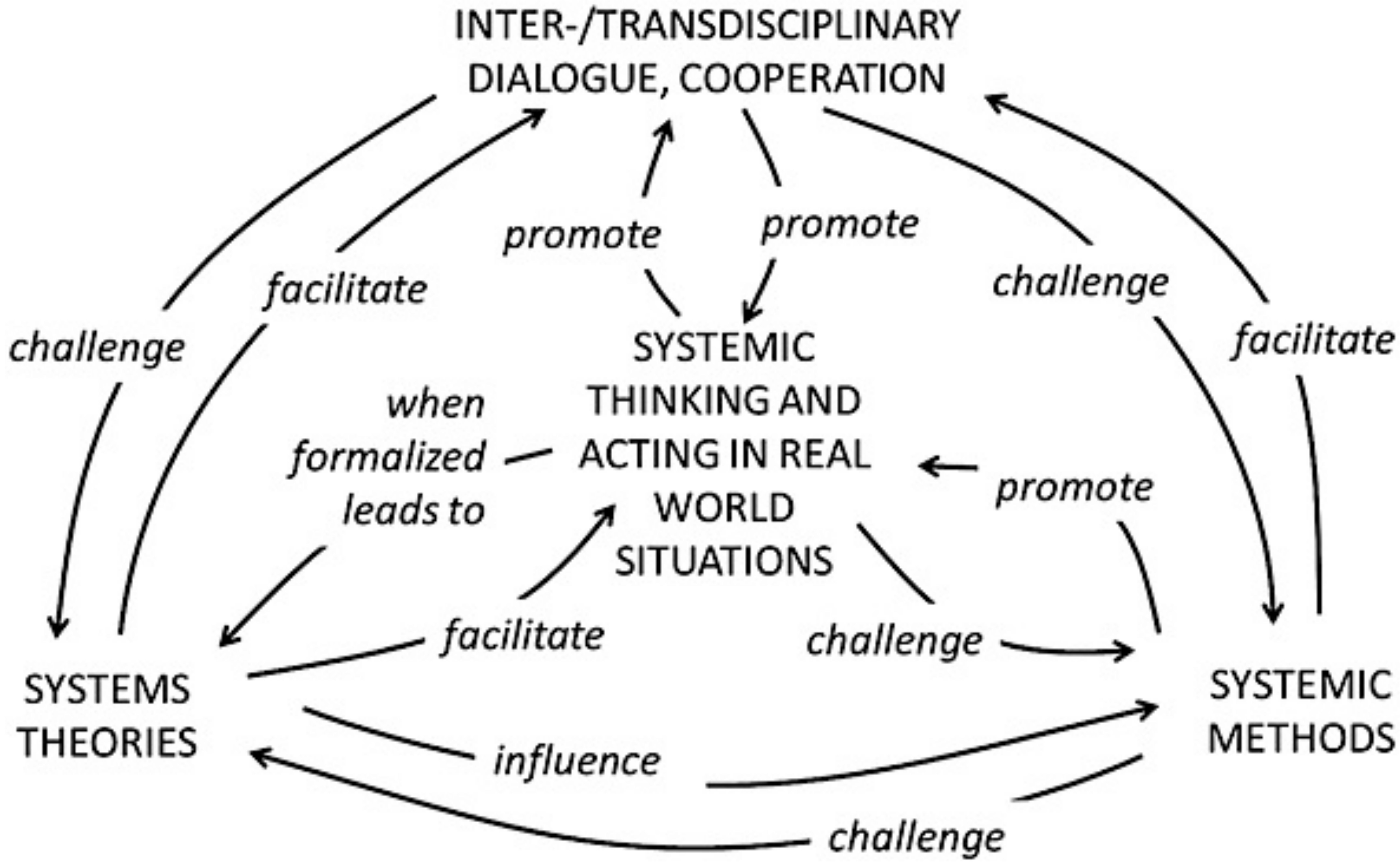
Two extremes of defining a ‘system’. Left: A ‘system’ in the sense of simple elements with relations. Right: A ‘system’ in the sense of an adaptive agent interacting within a dynamic environment, that itself is a system of systems

Hieronymi, 2013



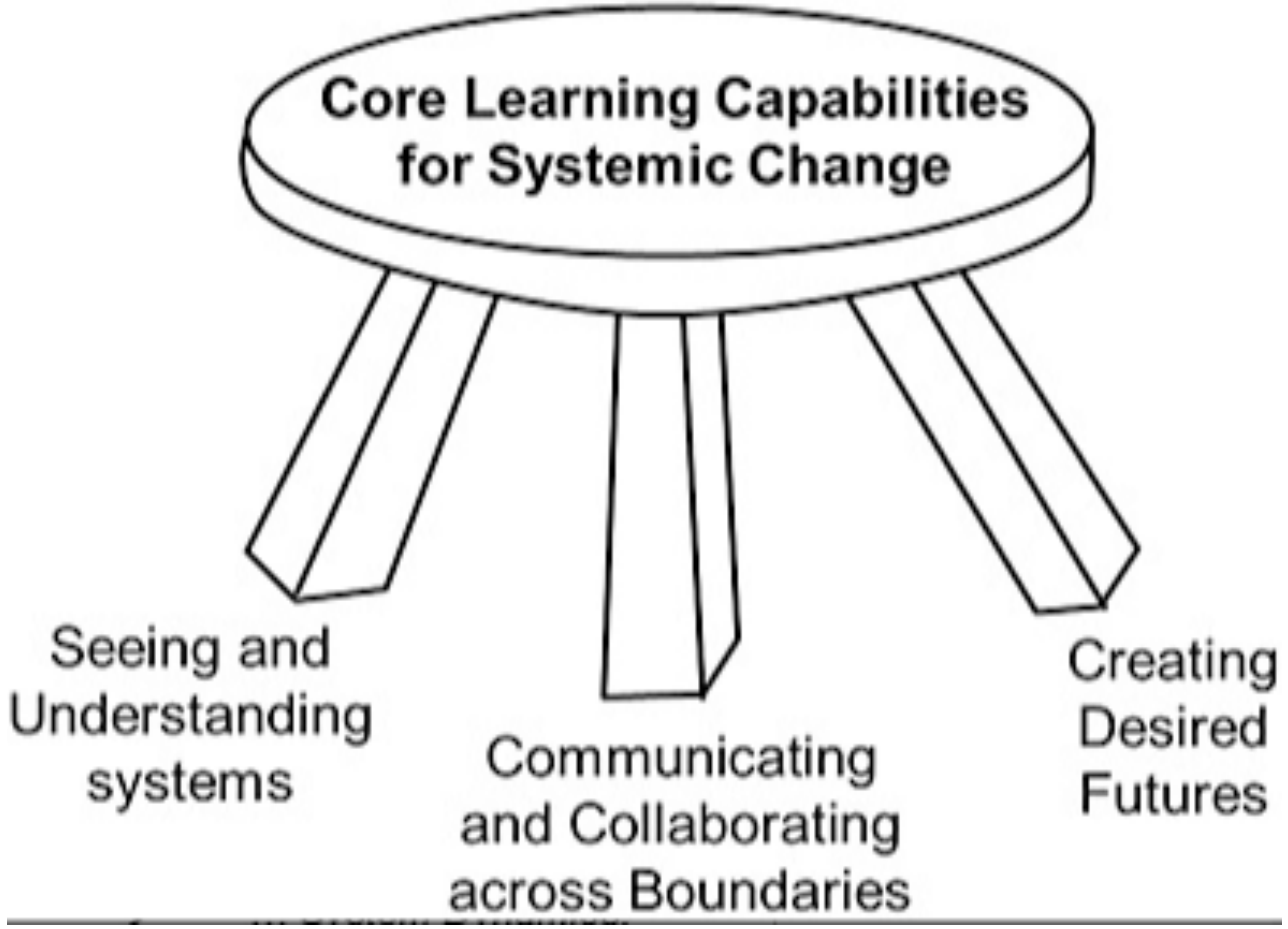
Proposed process cycle involving four general steps to illustrate systemic aspects and methodologies

Hieronymi, 2013



Mutual influence of four components in the systems field (adapted from Flood and Carson, 1993, p. 4)

Hieronymi, 2013



Three capabilities for systemic change. (Adapted from Senge *et al.*, 2010, p. 45)

Hieronymi, 2013

Mitigation and Adaptation Studies

Class 5: Systems Science and Systems Thinking

Contents:

- *Systems Science*
- *Systems Thinking*
- *The Earth's Life-Support System*
- *Systems Thinking and Modern Global Change*

Systems Thinking

There are two distinctive **perspectives**: **event-oriented thinking** and **systems thinking**.

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Event-oriented thinking:

- Most people, probably over 95%, are event oriented.
- They see the world as a collection of parts and events.
- Each event has a cause and to solve a problem, the cause needs to be found and fixed.
- Global environmental sustainability problem:
- People's misbehavior is the cause of the problem.
- The solution, then, is to get them to stop behaving so irresponsibly.
- This can be done with laws stating what to do and not to do, plus emotional appeals to be nice to the environment.
- When that solution fails, the problem is called a hard problem.

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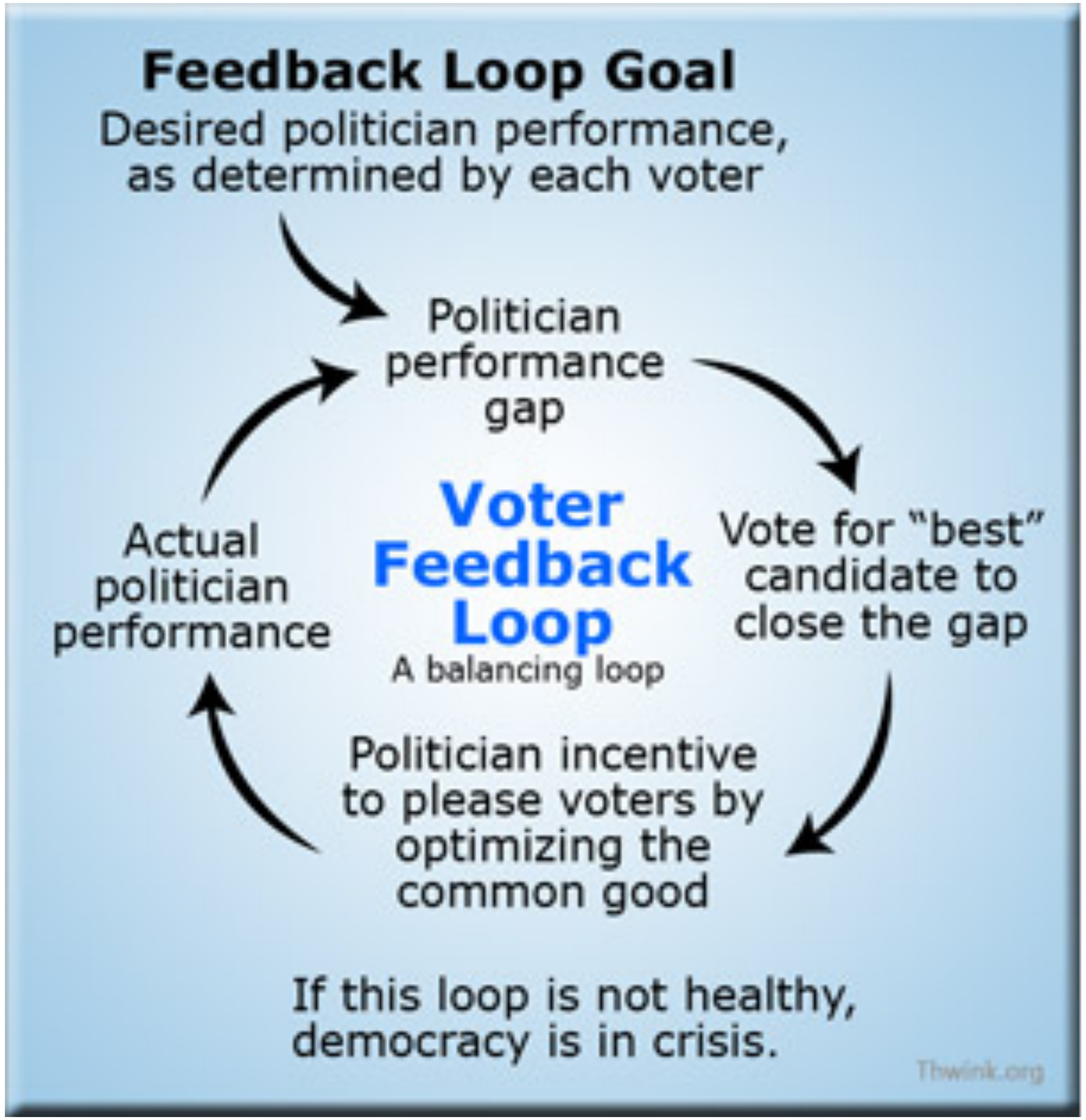

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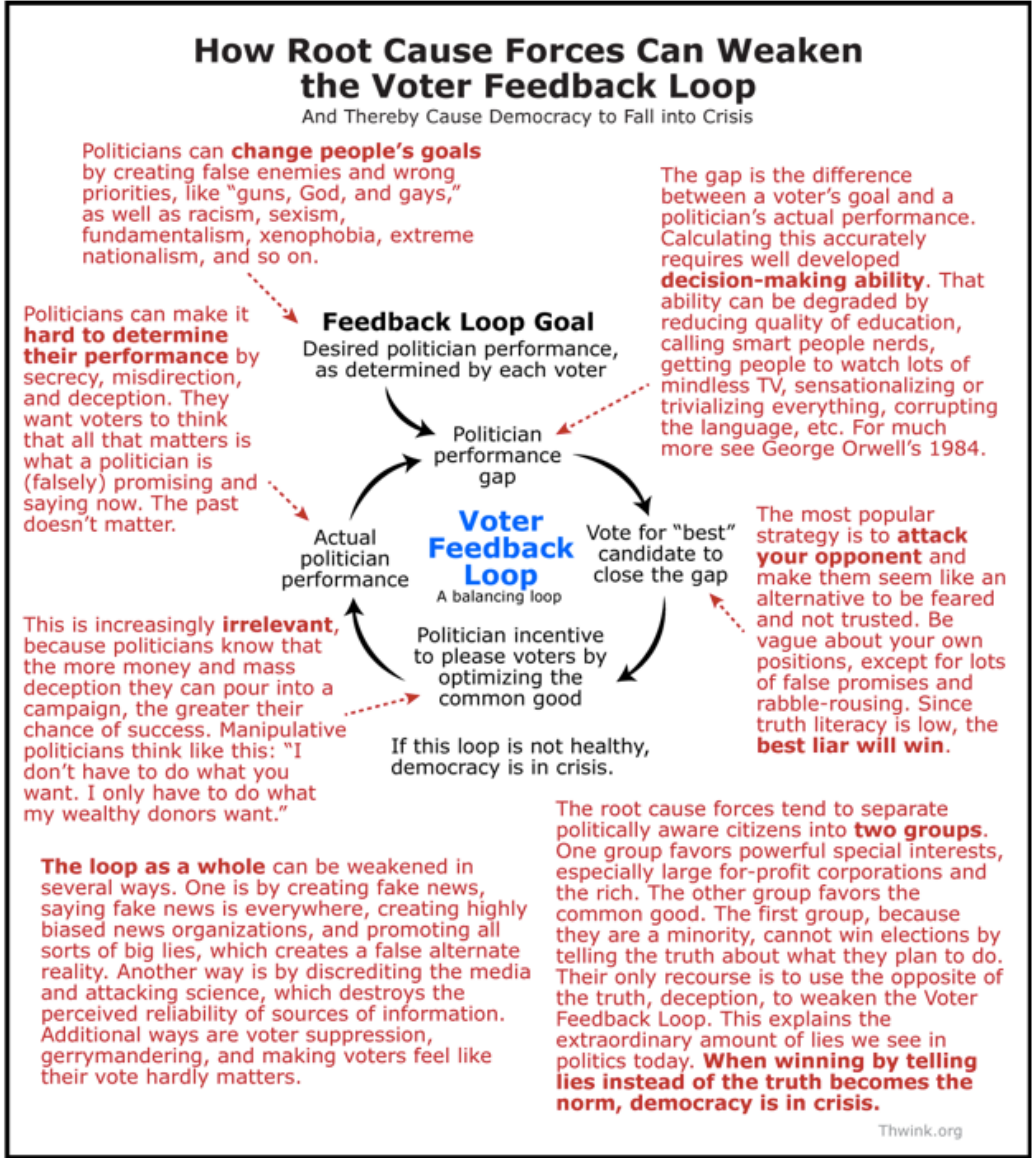

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Systems thinking:

- Views problems entirely differently:
- E.g., global environmental unsustainability is the result of immense positive feedback loops causing swarms of societal agents to exploit the Earth for their own benefit and population growth.
- This mode becomes unsustainable when negative feedback loops finally start to push back as environmental limits are approached.
- Doesn't see people's misbehavior as the problem.
- Instead, the structure of the system is seen as causing that misbehavior.
- To solve the problem, system structure must be understood and changed, so that feedback loops can be redesigned to cause people to behave sustainably as a natural part of their everyday existence.
- This takes far more work than writing a few quick new laws and pleading to save the world.

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Systems thinking is a perspective of a community on wholes, parts and their relationships.

Systems Thinking

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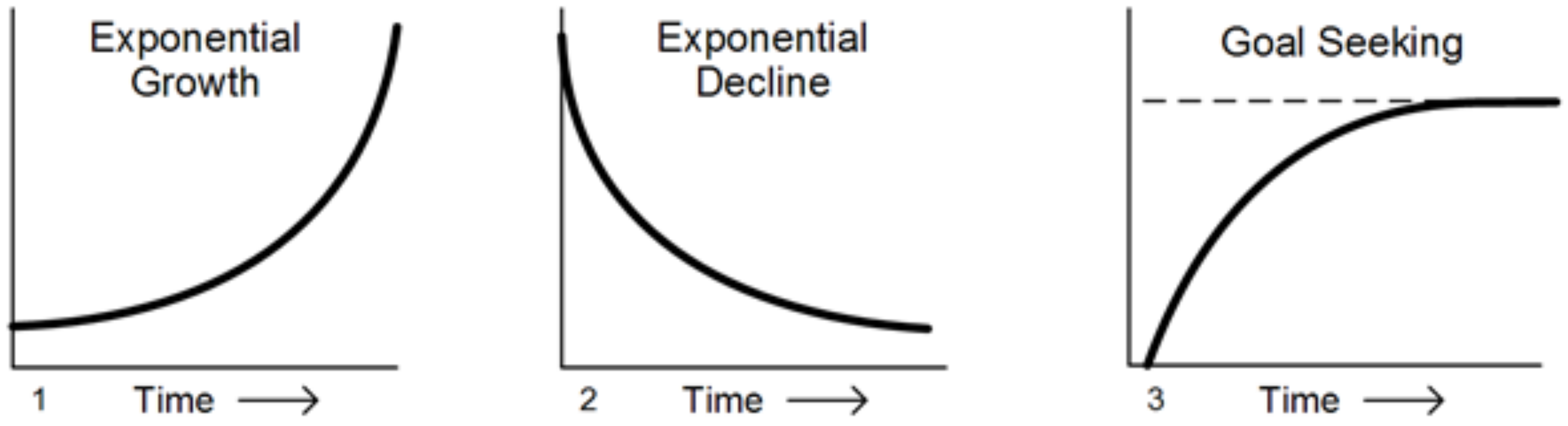

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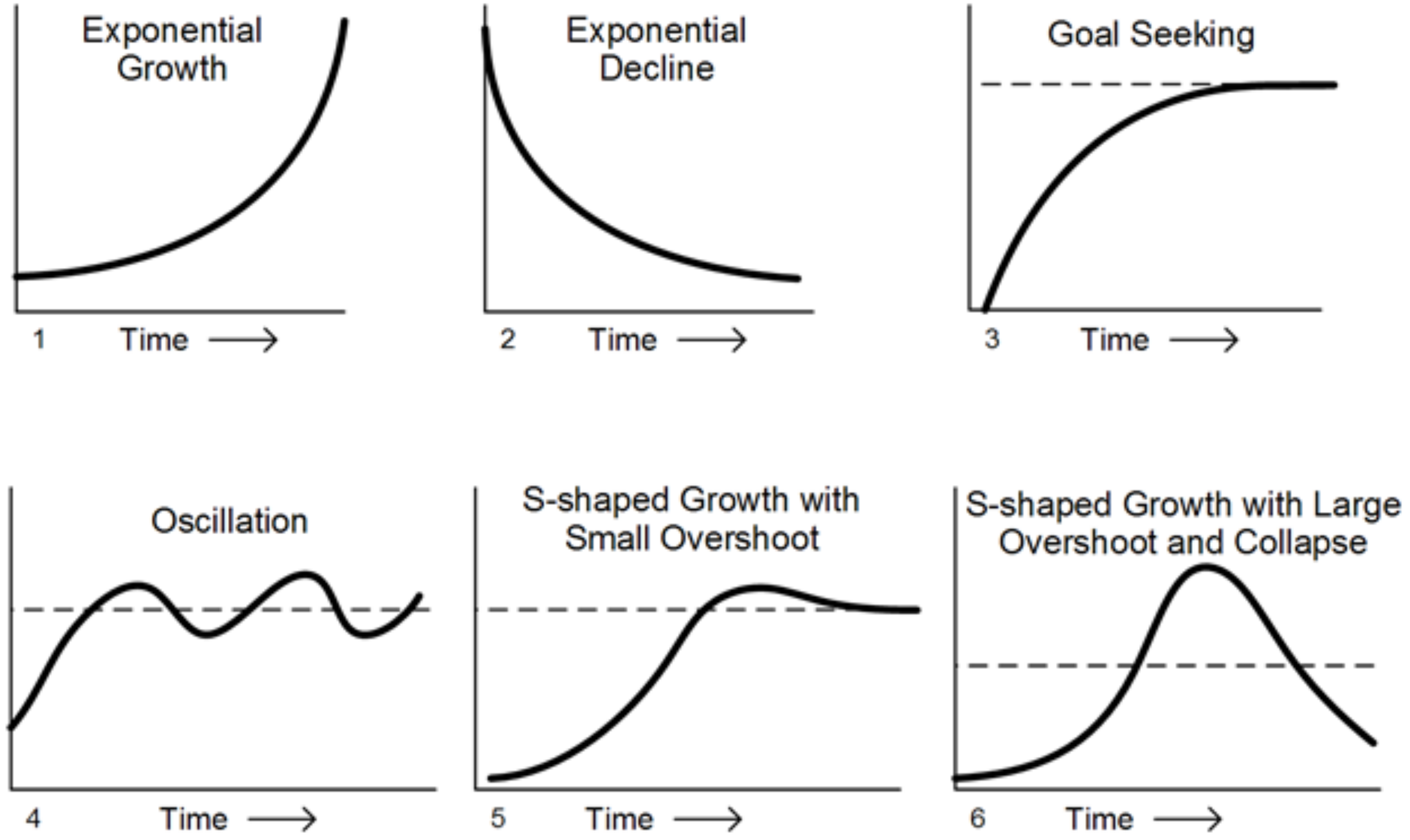
A fundamental principle of system dynamics states that the structure of the system gives rise to its behavior.



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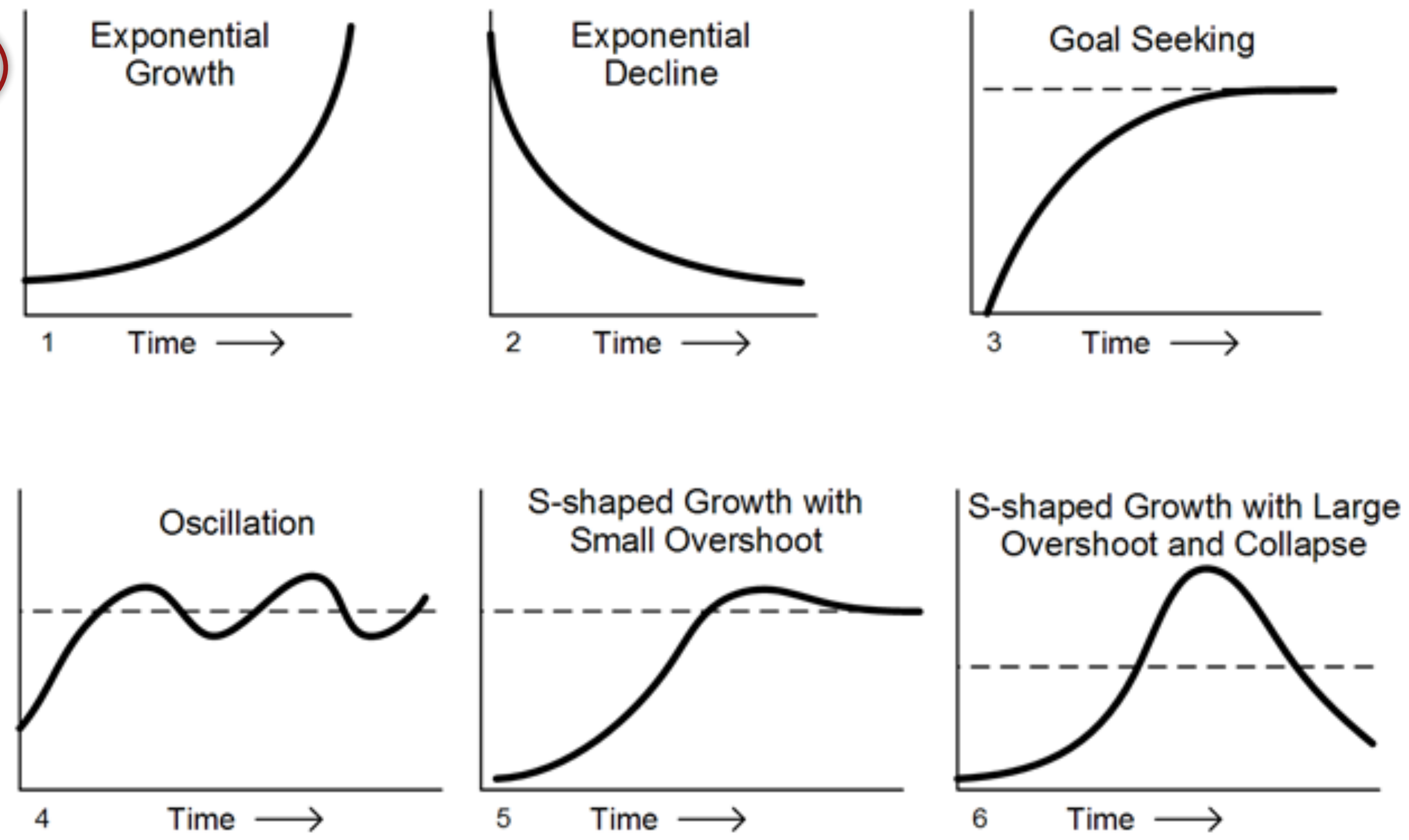
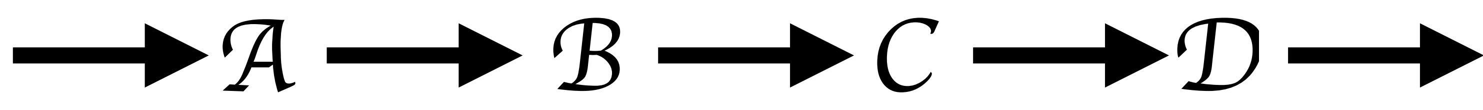
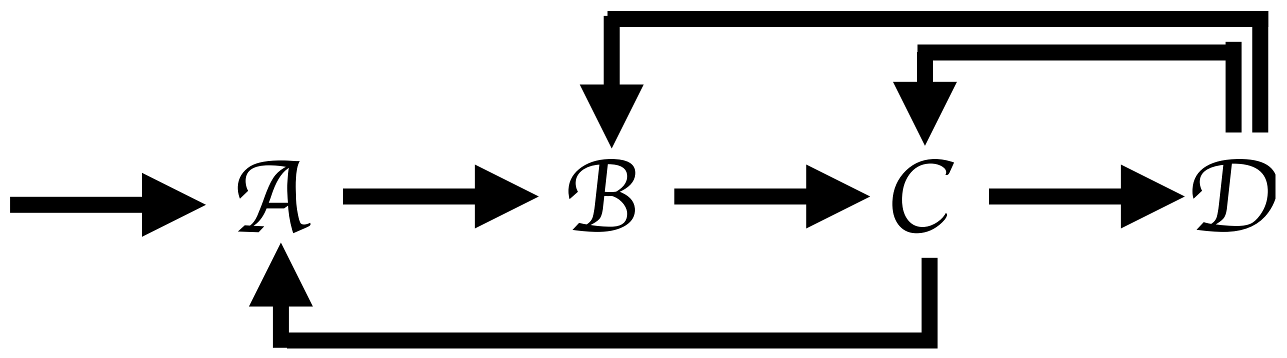


Systems Thinking

Linear view: $\longrightarrow \mathcal{A} \longrightarrow \mathcal{B} \longrightarrow \mathcal{C} \longrightarrow \mathcal{D} \longrightarrow$

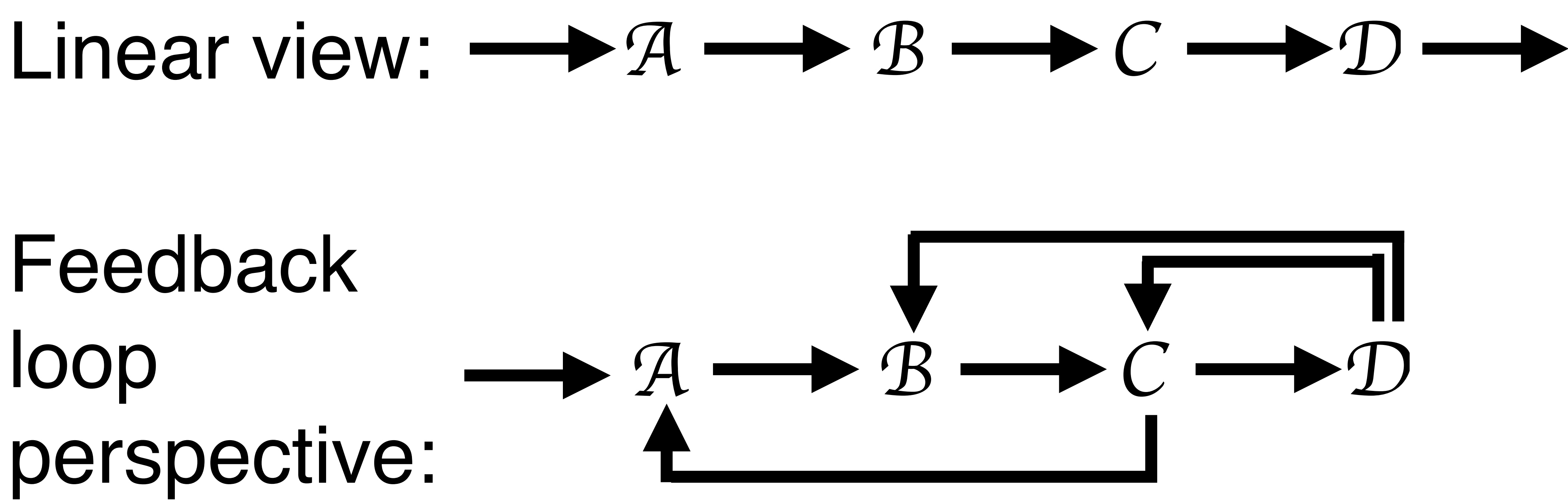
Systems Thinking

Linear view: 

Feedback loop perspective: 

Principles of Systems Thinking

1. A feedback loop is system structure that causes output from a node to eventually influence the input to that same node.
2. A feedback loop is either reinforcing or balancing.
3. The behavior of all dynamic systems is a result of its feedback loops.
4. The important behavior of a system emerges from its key feedback loops.
5. The behavior of a large complex system is generally so counterintuitive that it cannot be correctly understood without modeling the system's key feedback loops.



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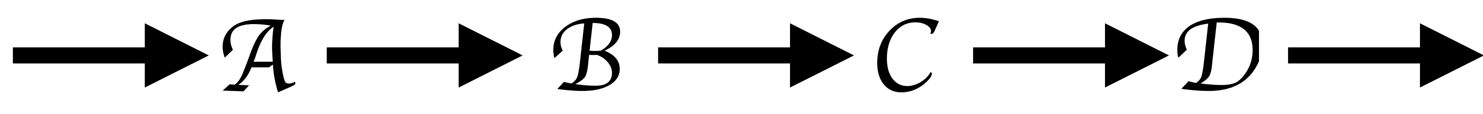

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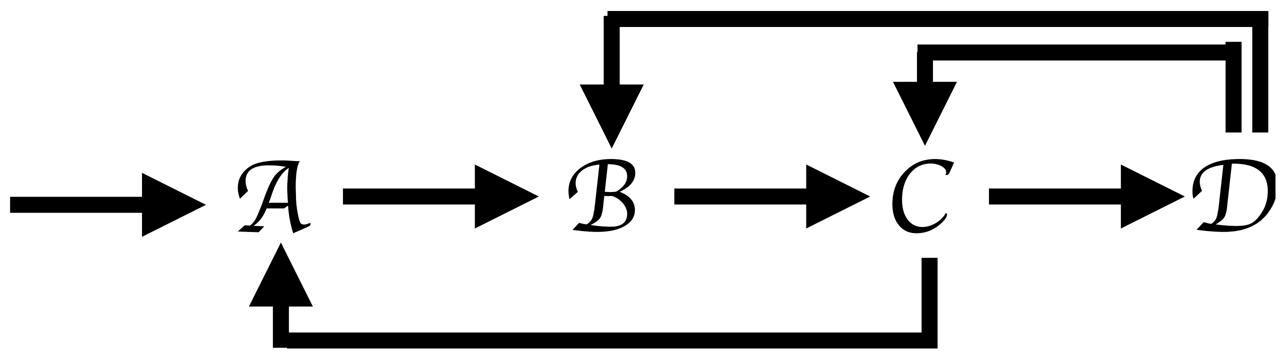

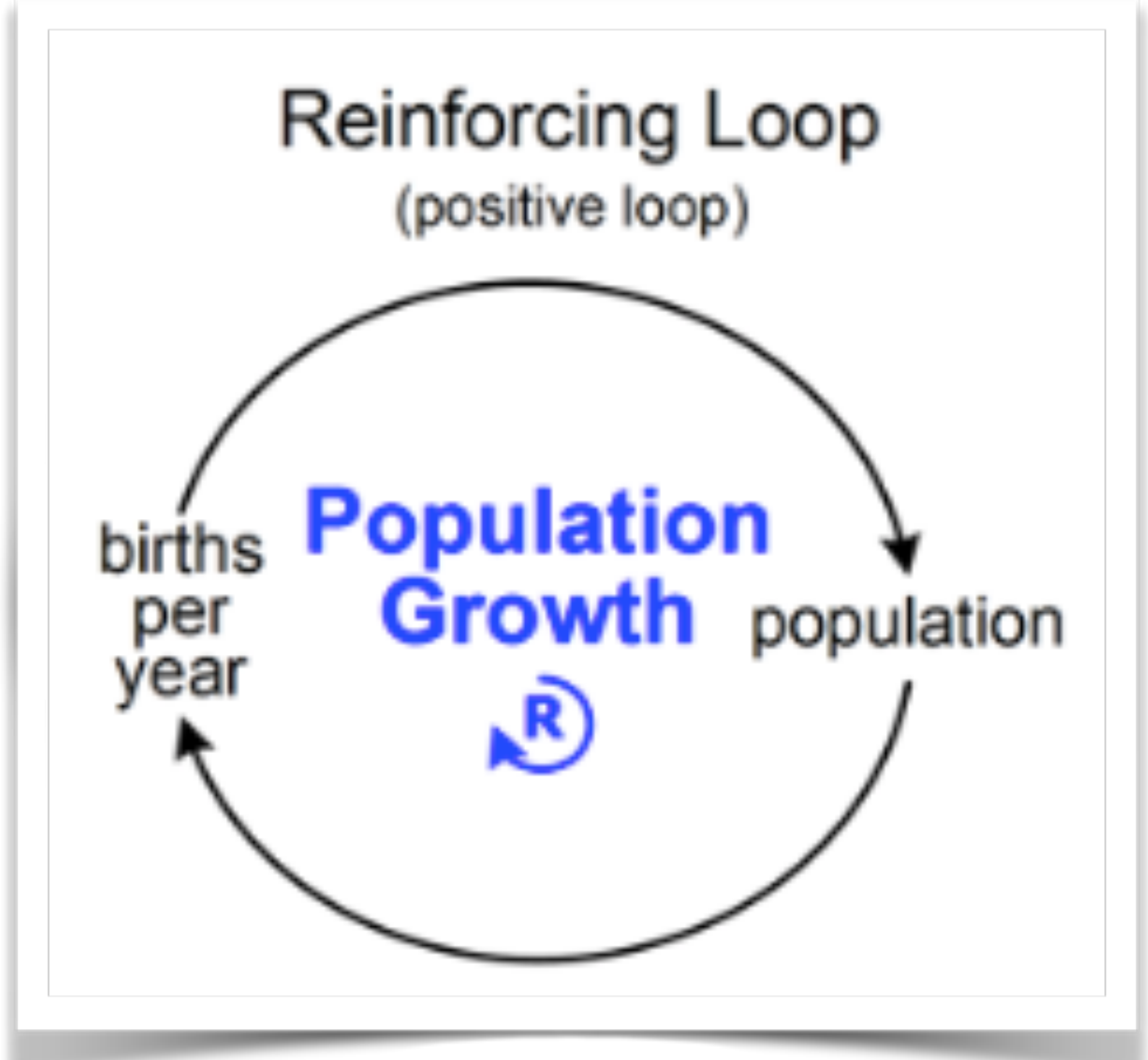

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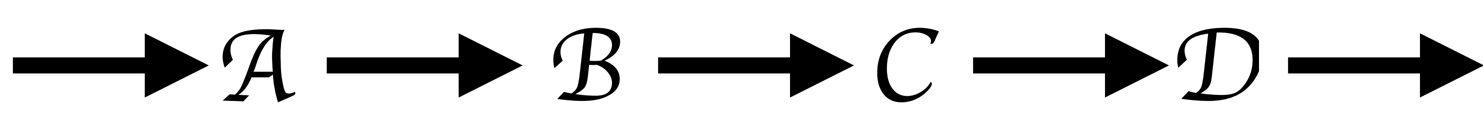
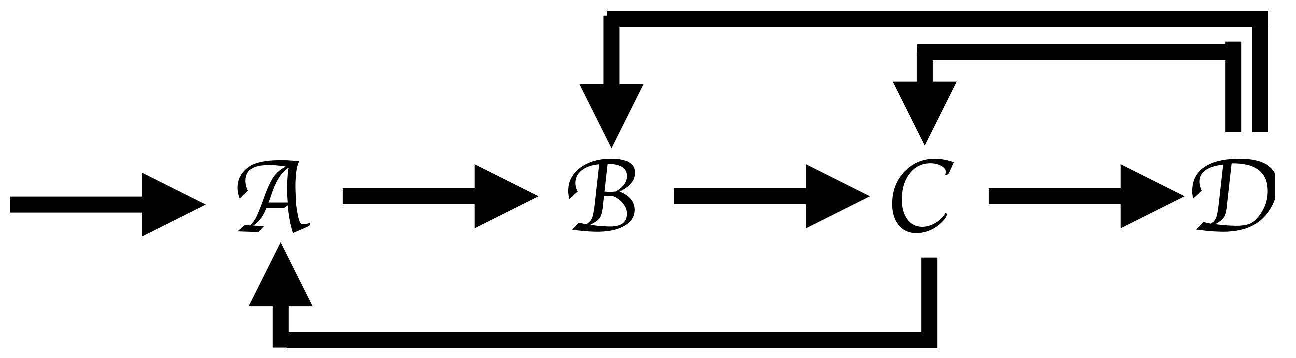
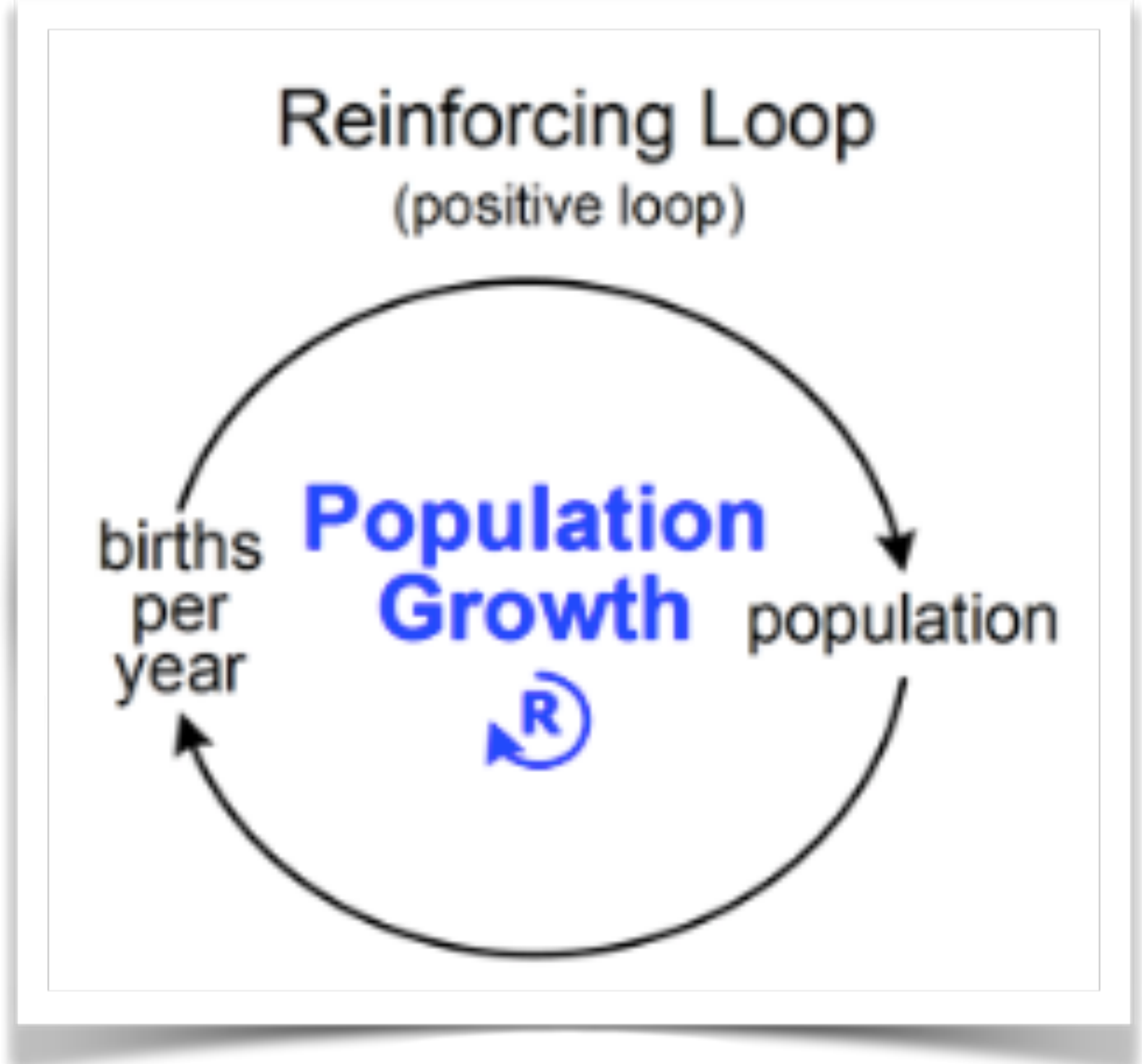
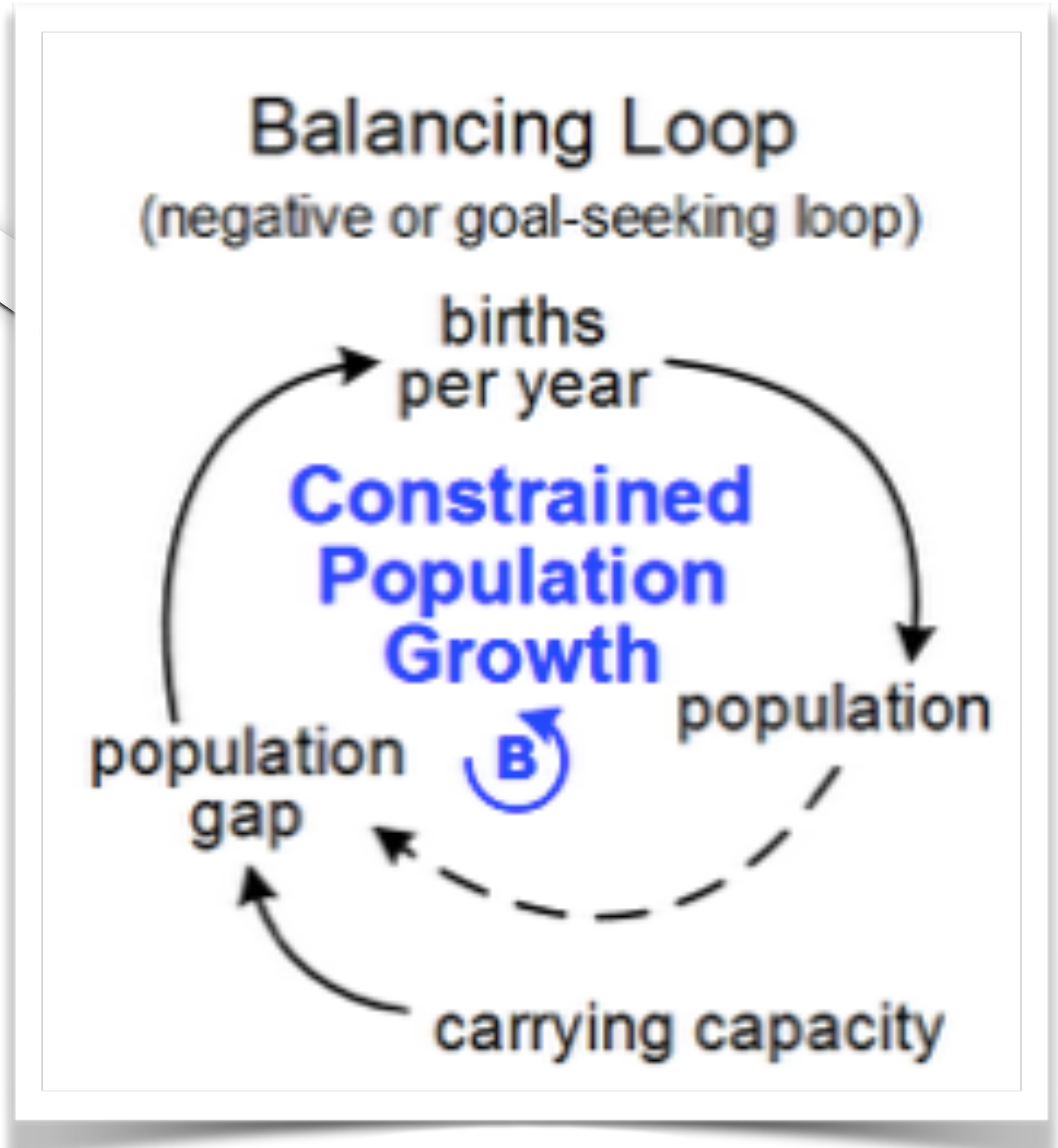


Feedback loop perspective:







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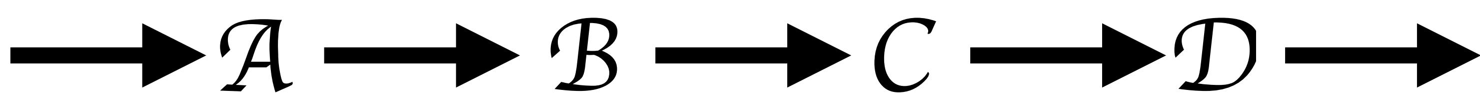

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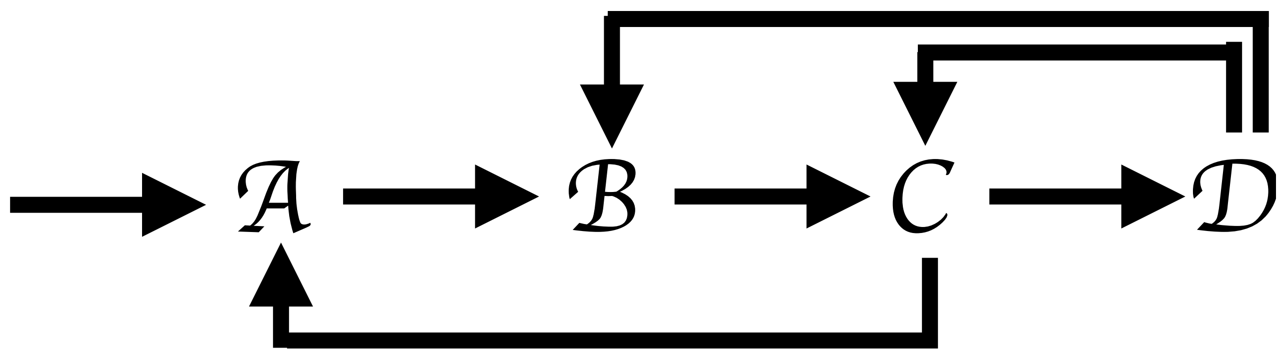

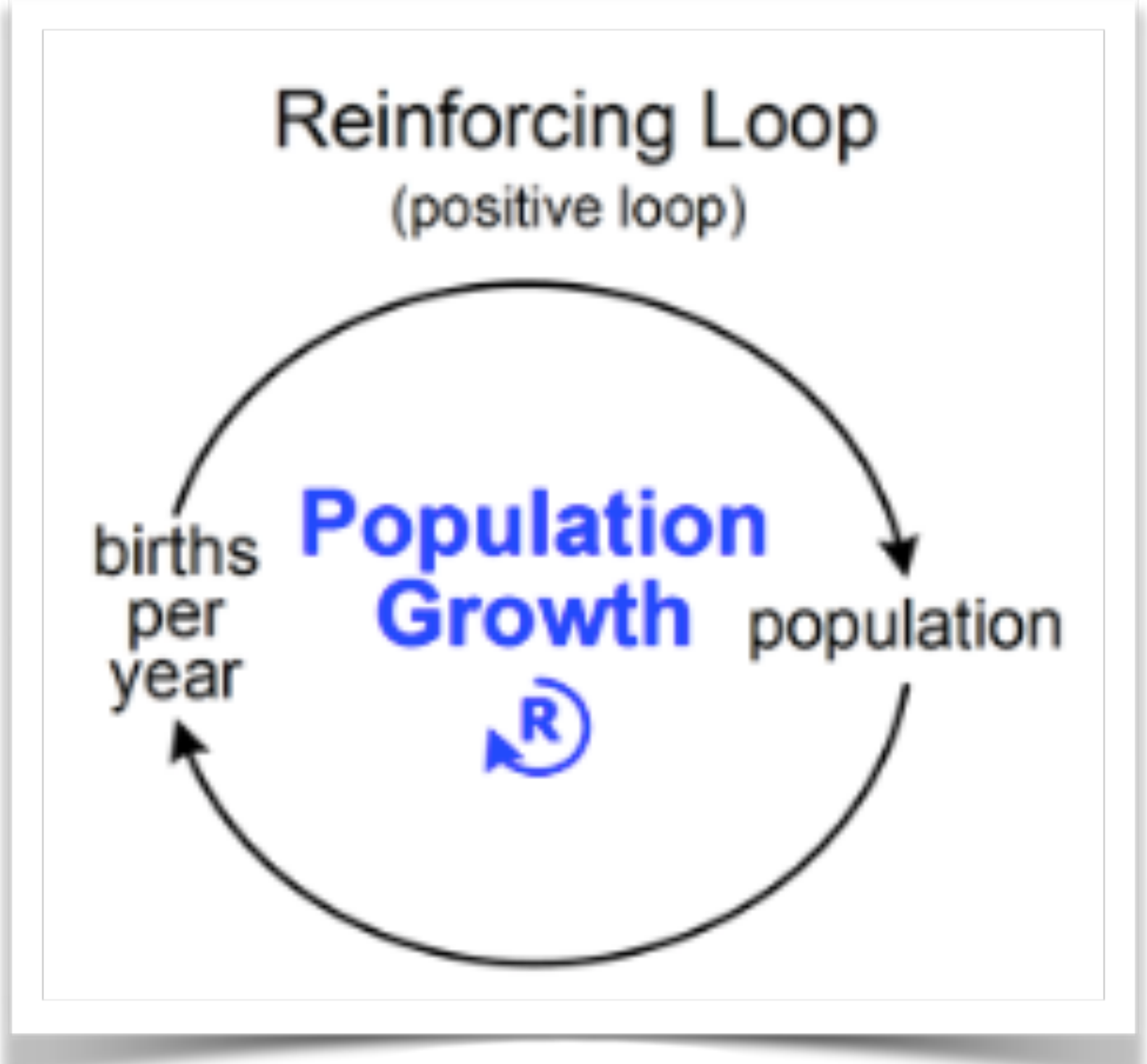

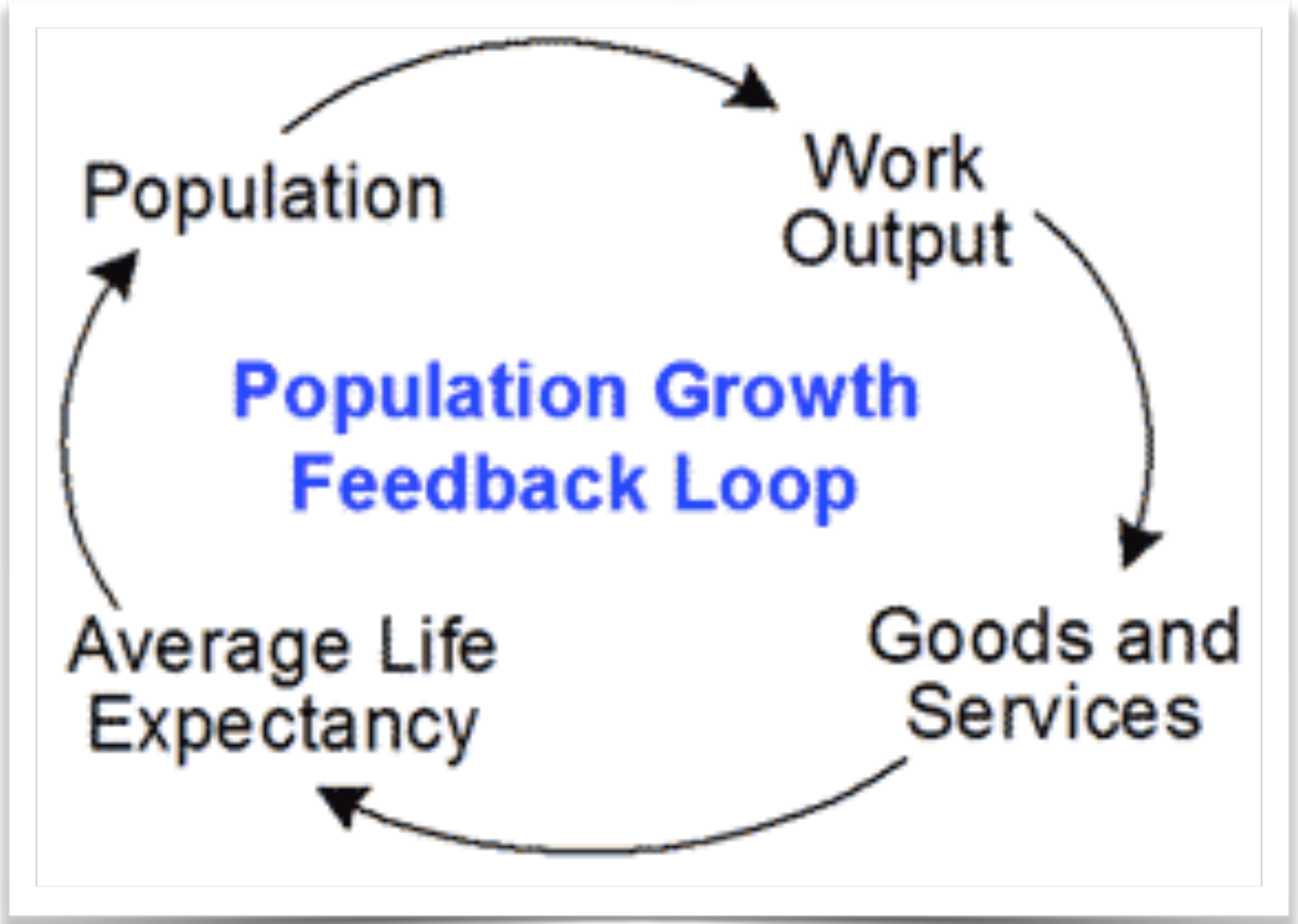

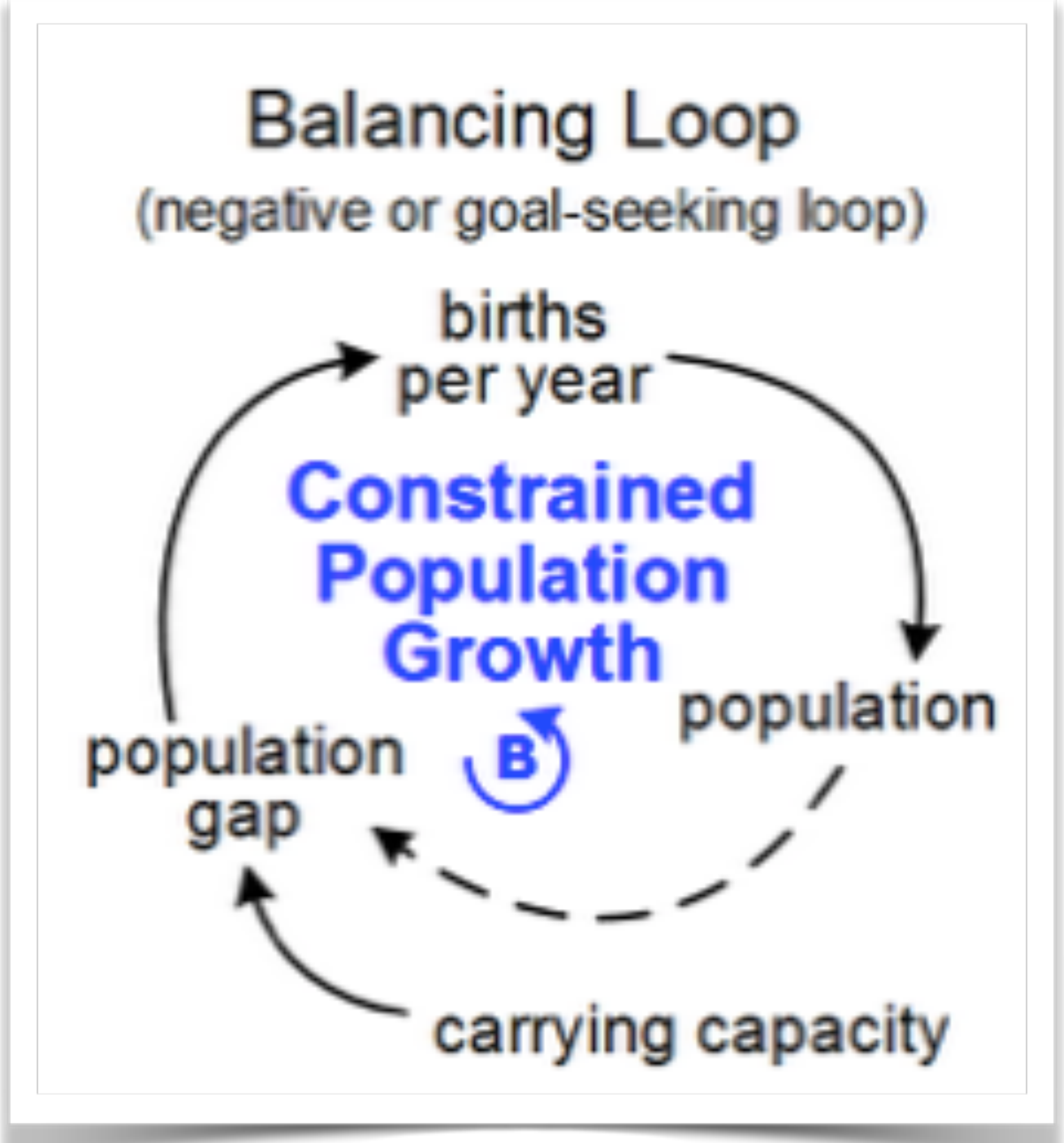

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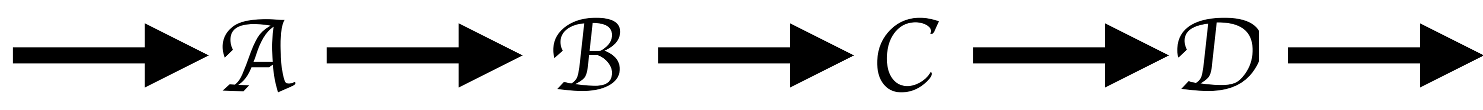

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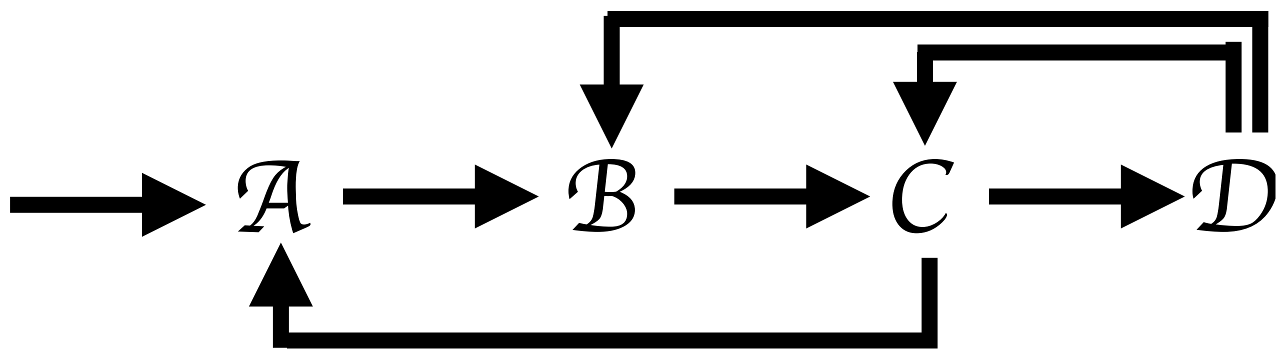

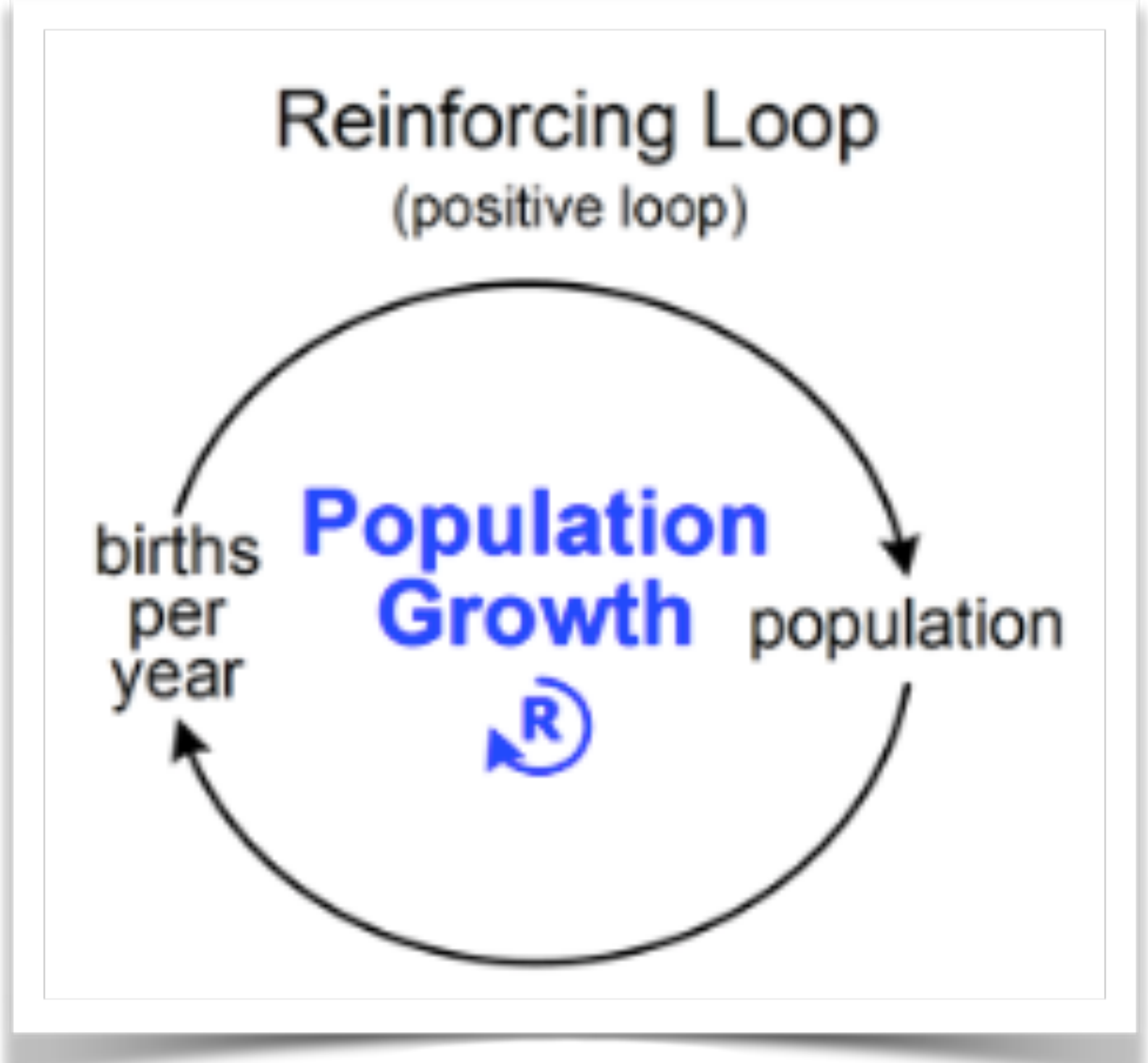

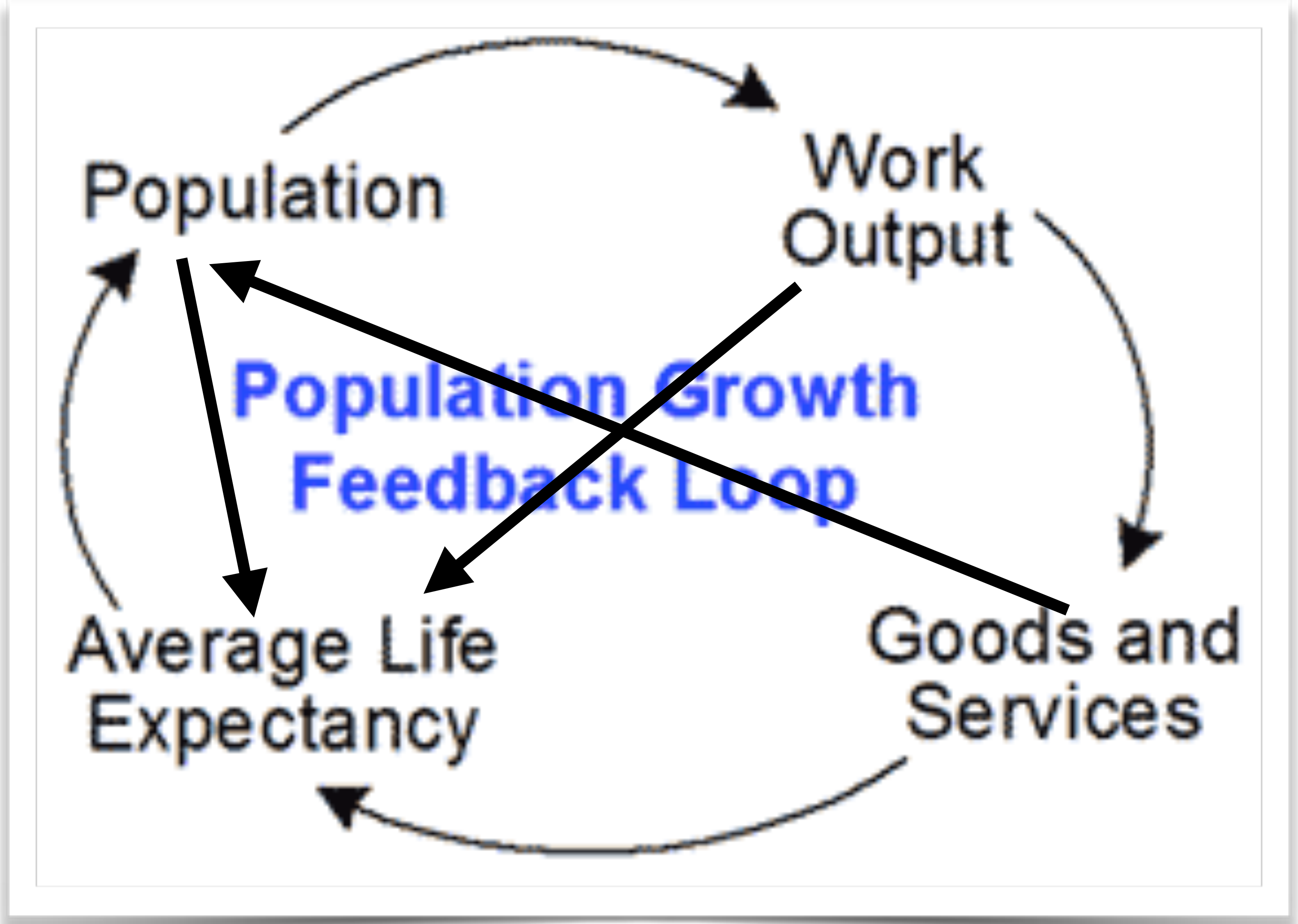

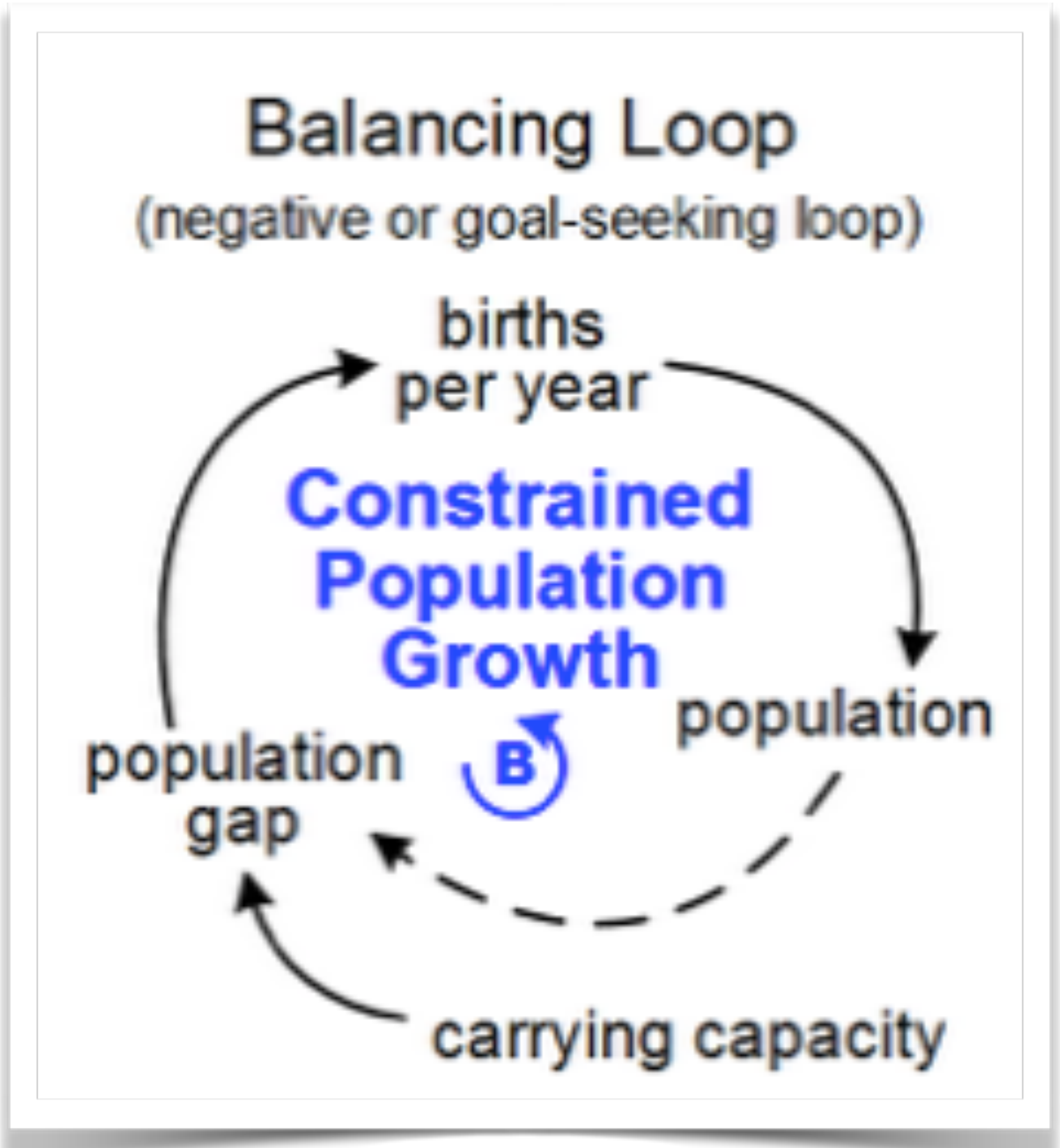

Systems Thinking

Key concepts of systems thinking

- Analysis
- Causal chain
- Causal loop diagram
- Feedback loop
- Fundamental attribution error
- Leverage point
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The path of influence running from a root cause to problem symptoms. Each link in the chain represents something in the real world. At one end of the chain is the root cause. At the other end is the symptoms it causes. The many links between the two ends are the intermediate causes.

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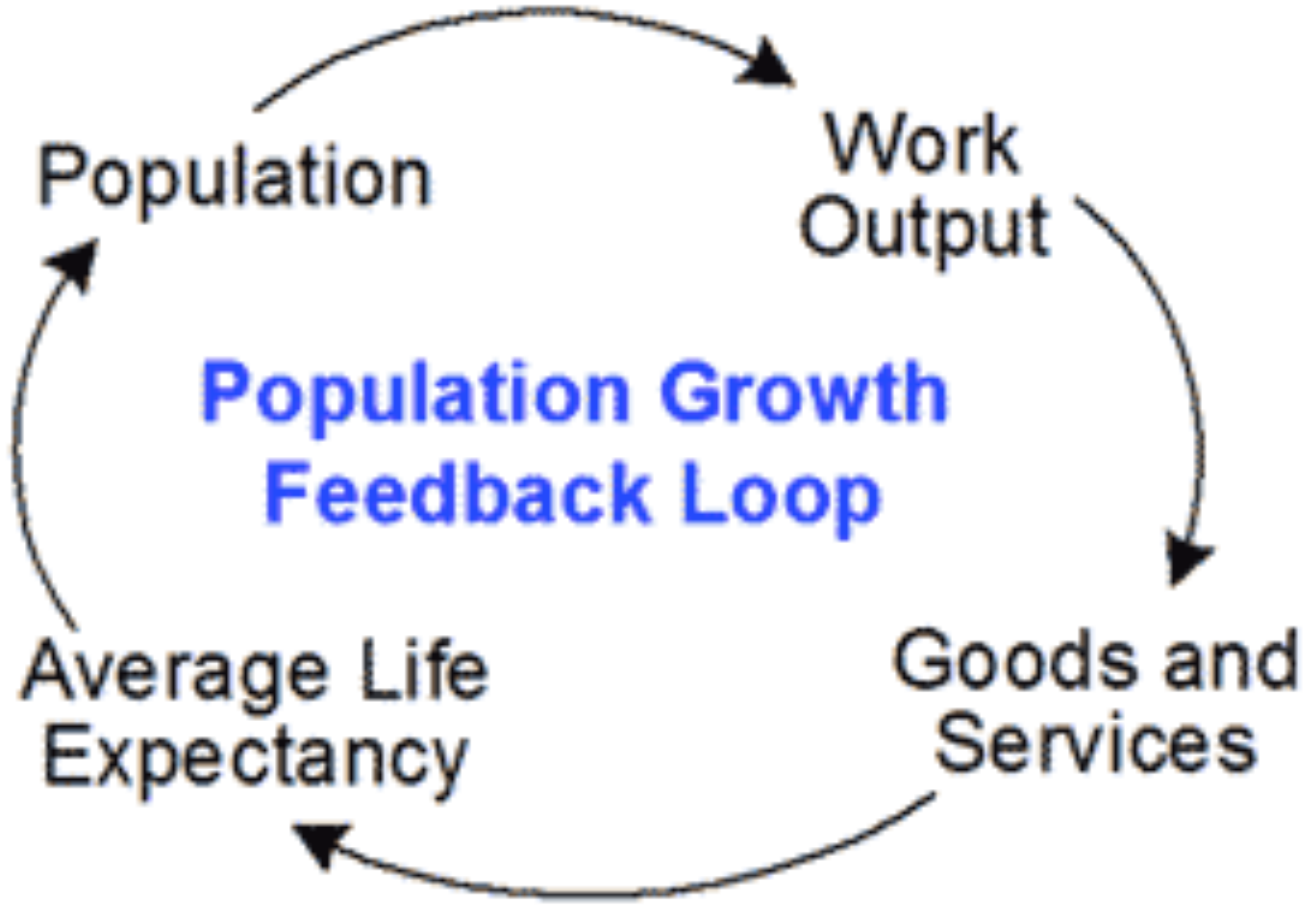

Analysis in the context of systems thinking is the process of the breaking down a complex problem into smaller easier to solve problems. This requires a formal process.

The path of influence running from a root cause to problem symptoms. Each link in the chain represents something in the real world. At one end of the chain is the root cause. At the other end is the symptoms it causes. The many links between the two ends are the intermediate causes.

A collection of connected nodes and the feedback loops created by the connections. One or more of the nodes represent the symptoms of the problem. The rest of the nodes are the causal chains causing the problem.

Systems Thinking

Key concepts of systems thinking

- Analysis
- Causal chain
- Causal loop diagram
- Feedback loop
- Fundamental attribution error
- Leverage point
- Root cause
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The tendency to blame the person rather than the system is so strong psychologists call it the "fundamental attribution error."

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A place in a system’s structure where a solution element can be applied. It's a low/high leverage point if a small amount of change force causes a small/ large change in system behavior.

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A place in a system's structure where a solution element can be applied. It's a low/high leverage point if a small amount of change force causes a small/large change in system behavior.

That portion of a system that, at the fundamental level, explains why the system's behavior produces the problem symptoms rather than some other behavior.

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A class of problem solving methods aimed at identifying the root causes of problems or events. ... The practice of root cause analysis is predicated on the belief that problems are best solved by attempting to *correct or eliminate root causes*, as opposed to *merely addressing the immediately obvious symptoms*

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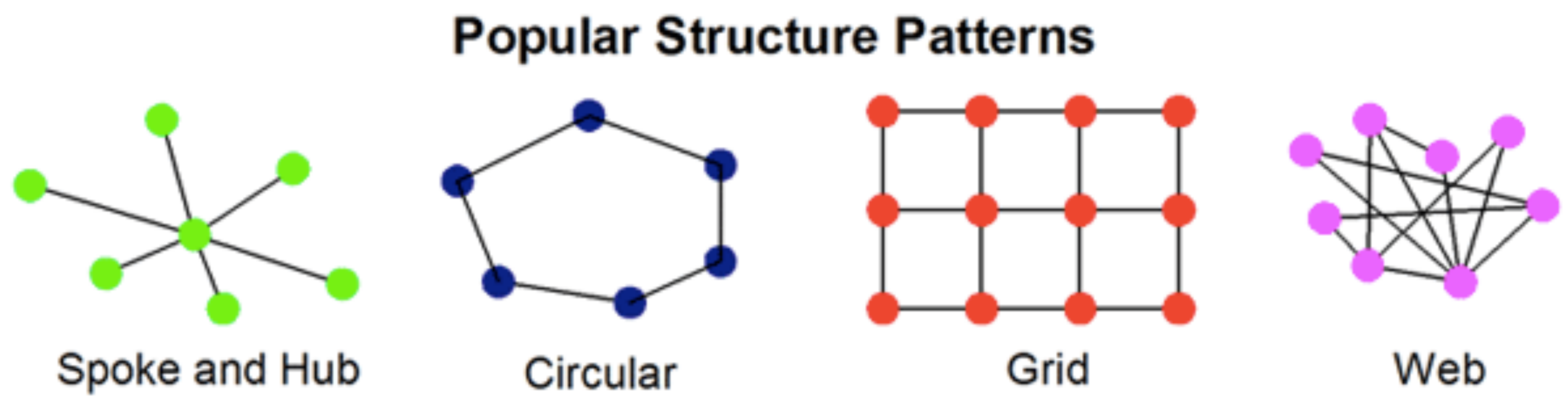
The way in which parts are arranged and connected to form a whole.



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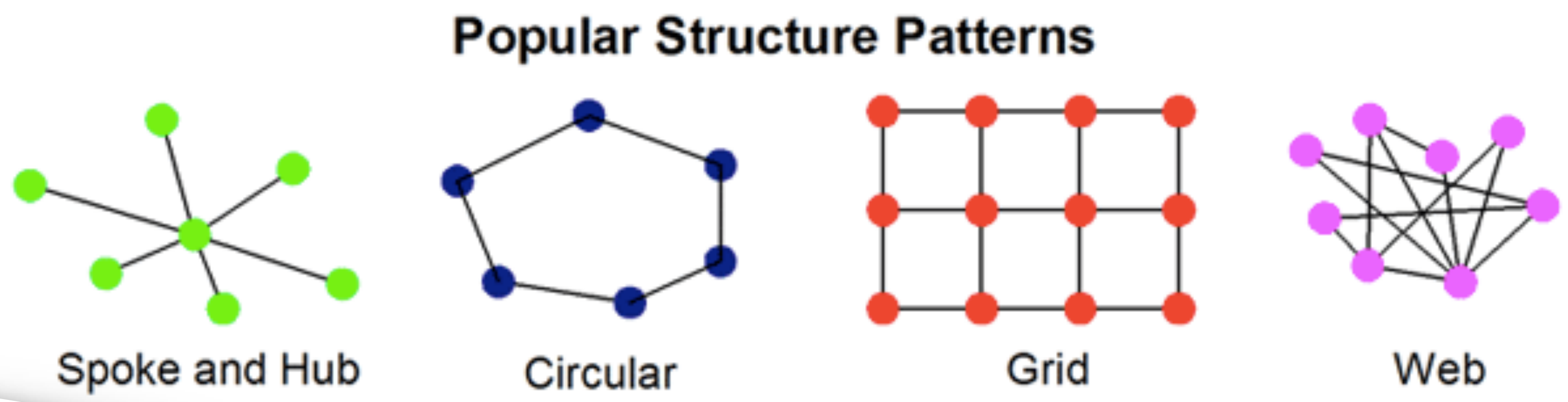

Something affecting most or all of a system rather than a small portion of the system.

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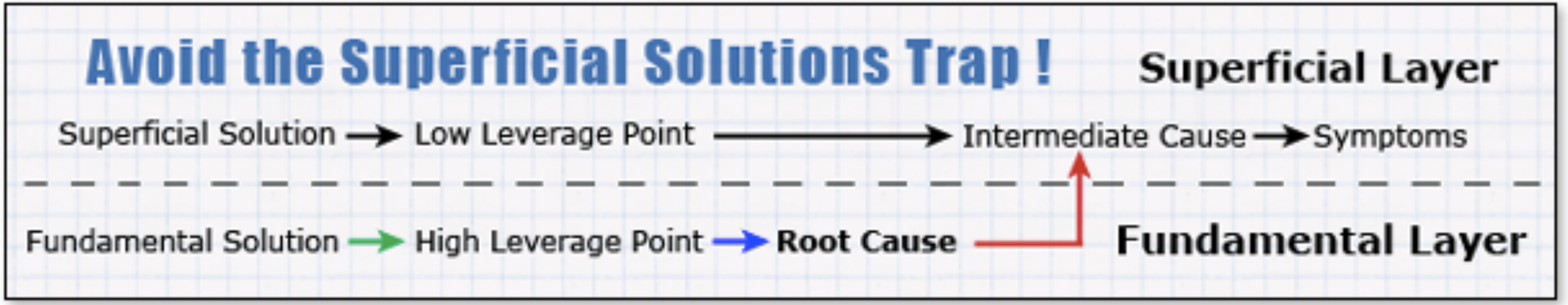

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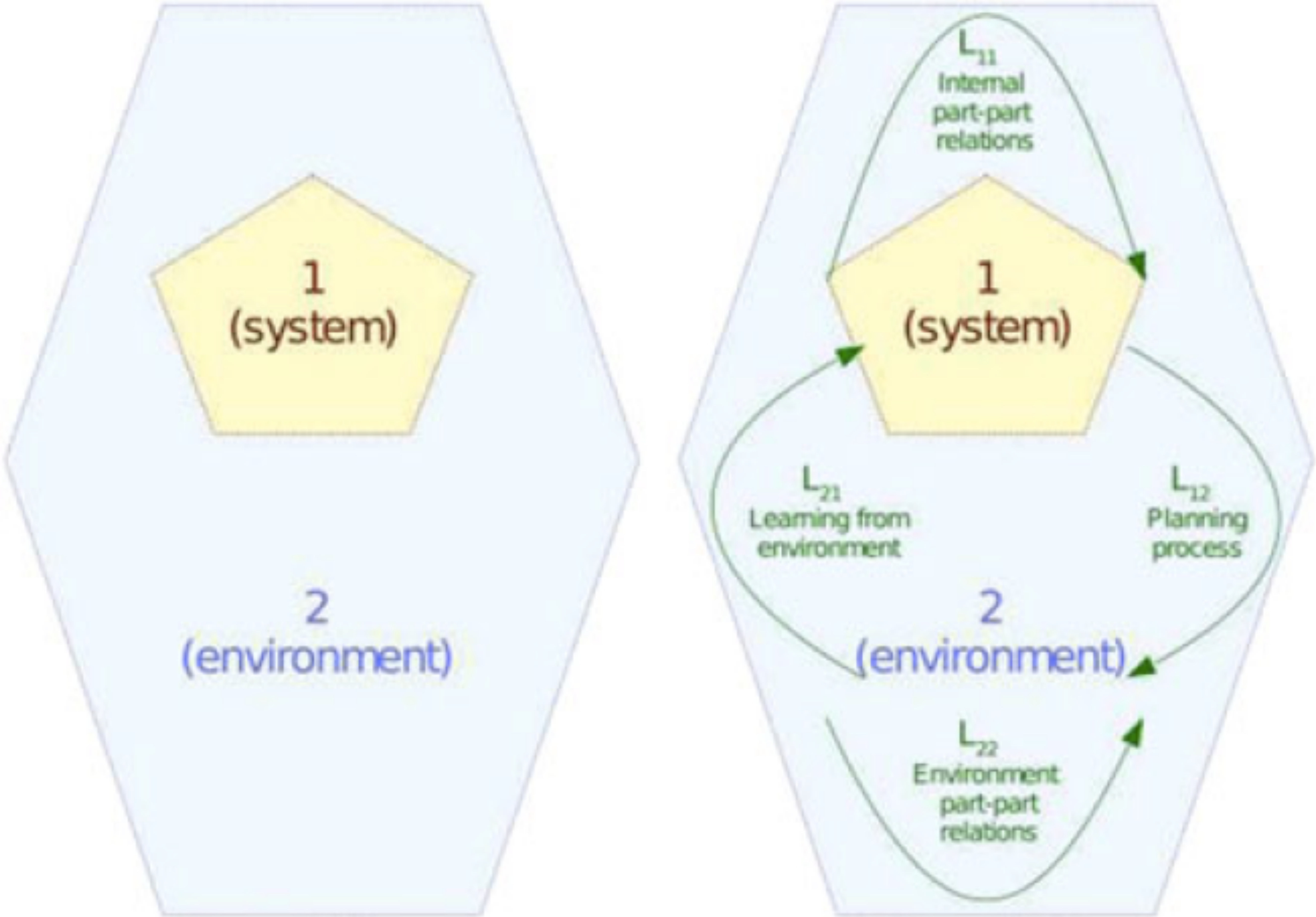

A system and its environment connect together as a field, with links emerging a causal texture.

Ing, 2013

Mitigation and Adaptation Studies

Class 5: Systems Science and Systems Thinking

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- *Systems Thinking*
- *Systems Science: Basic Concepts*
- *Systems Thinking and Modern Global Change*
- *The Earth's Life-Support System*

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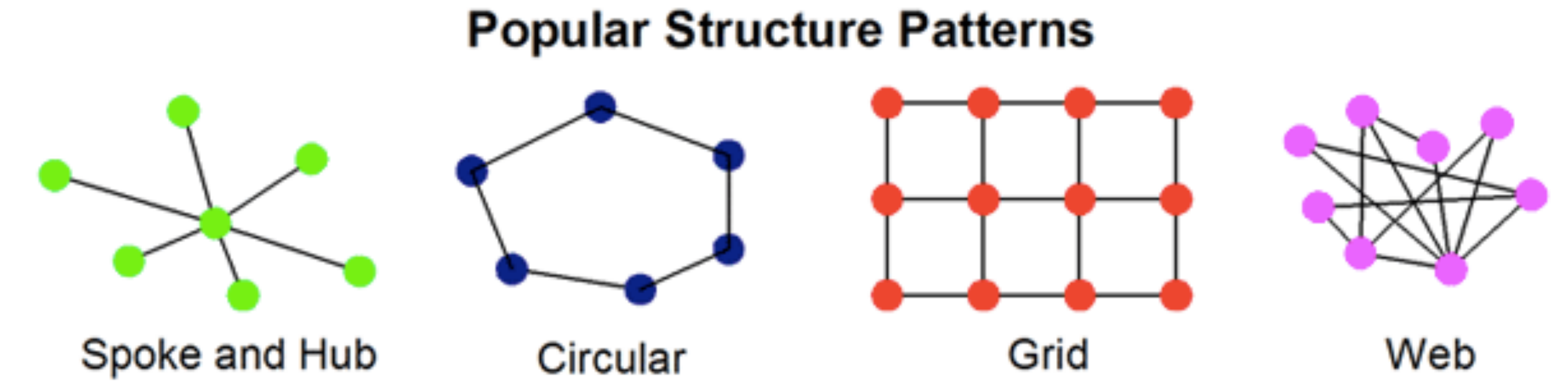

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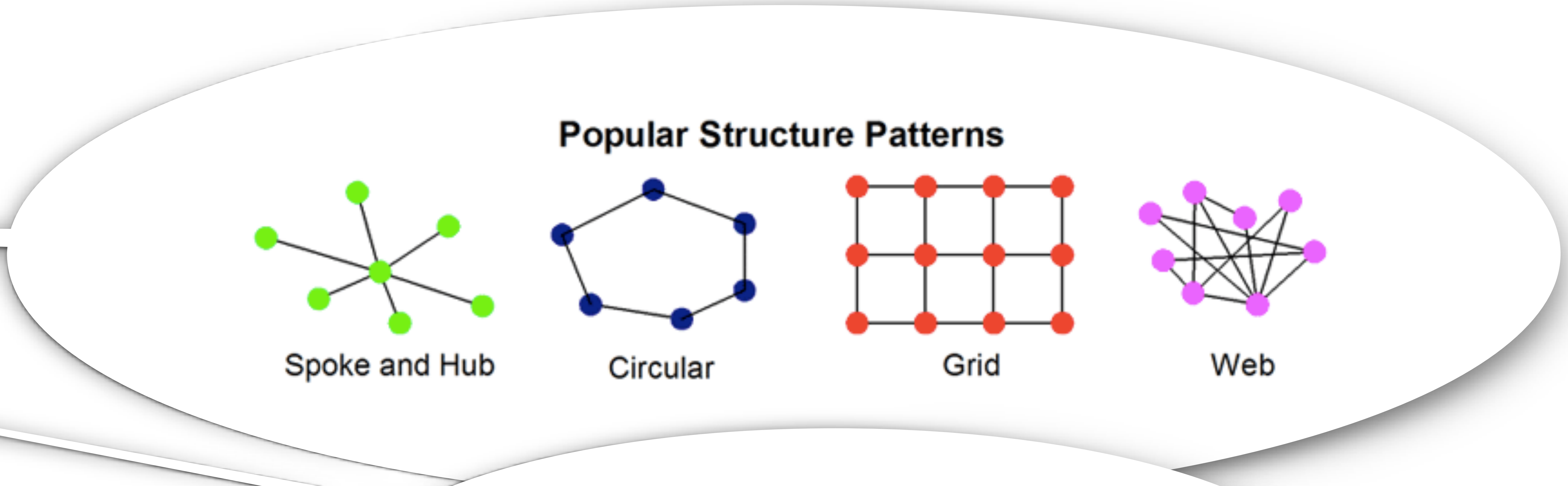

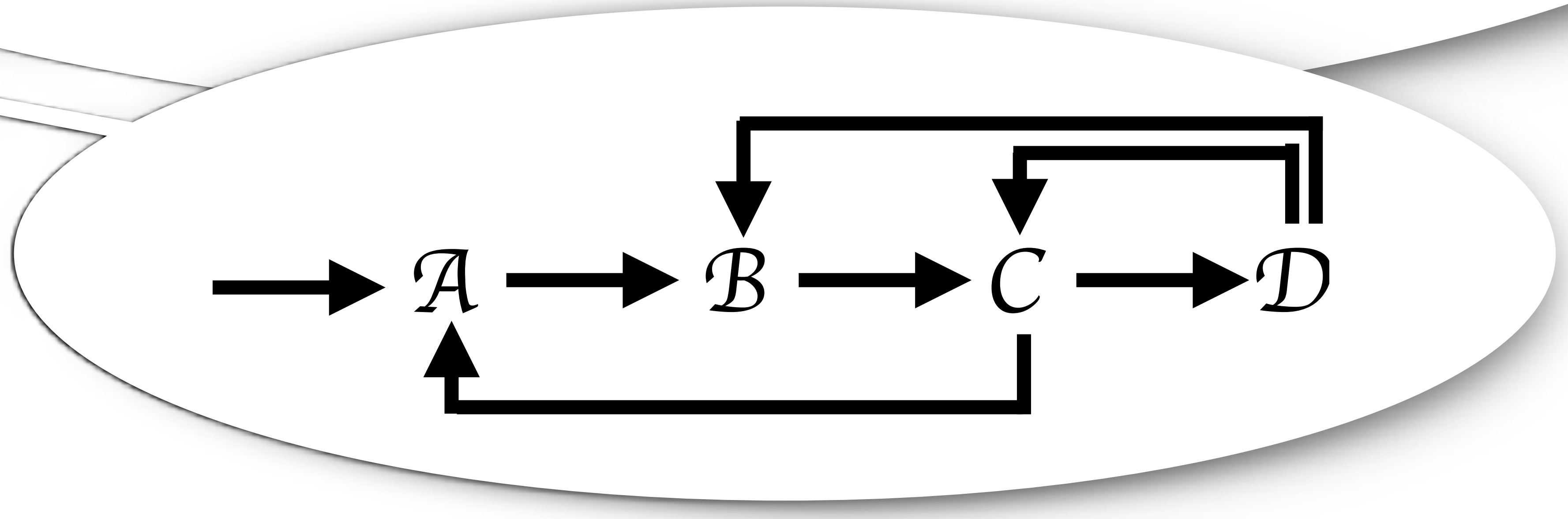

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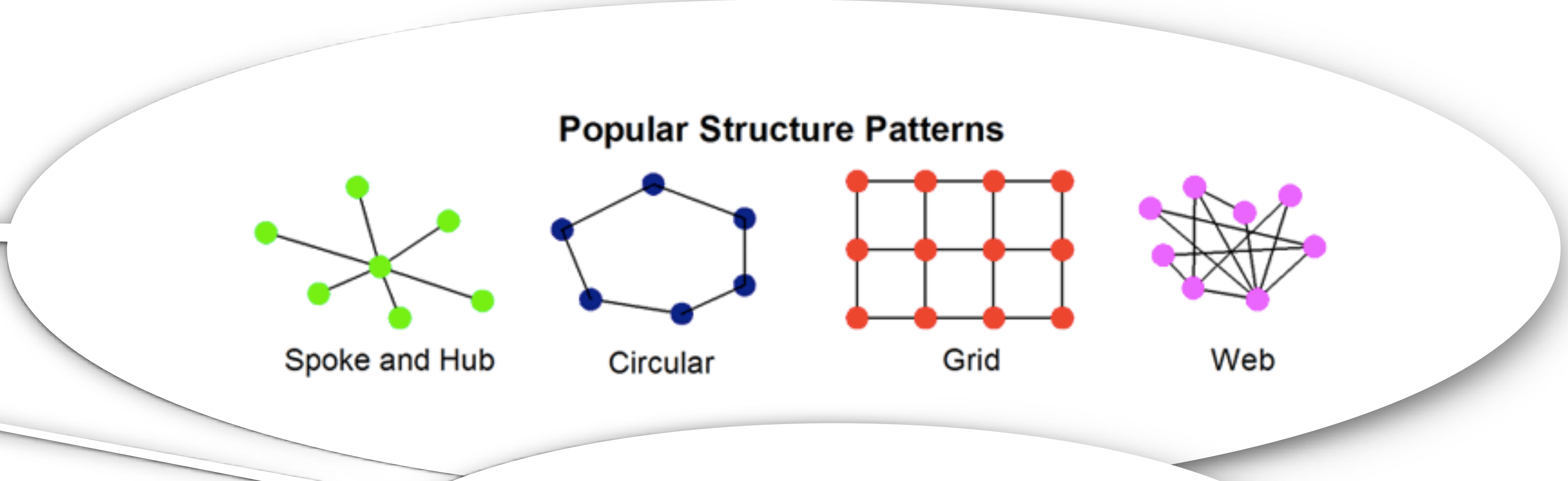

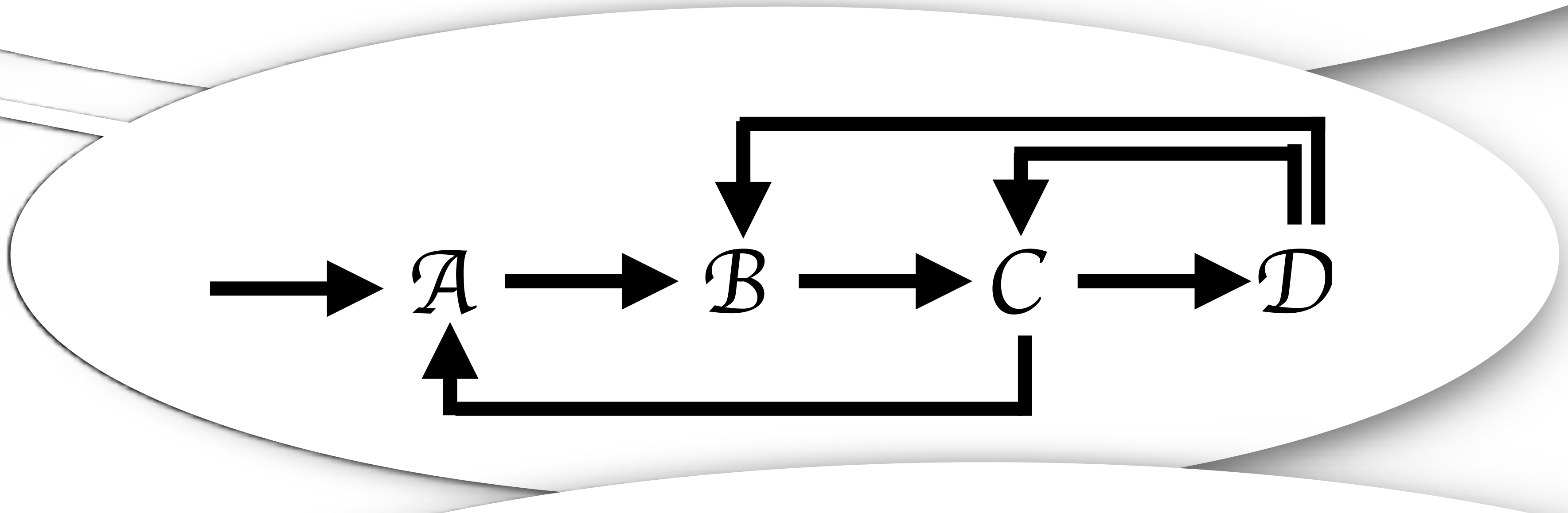

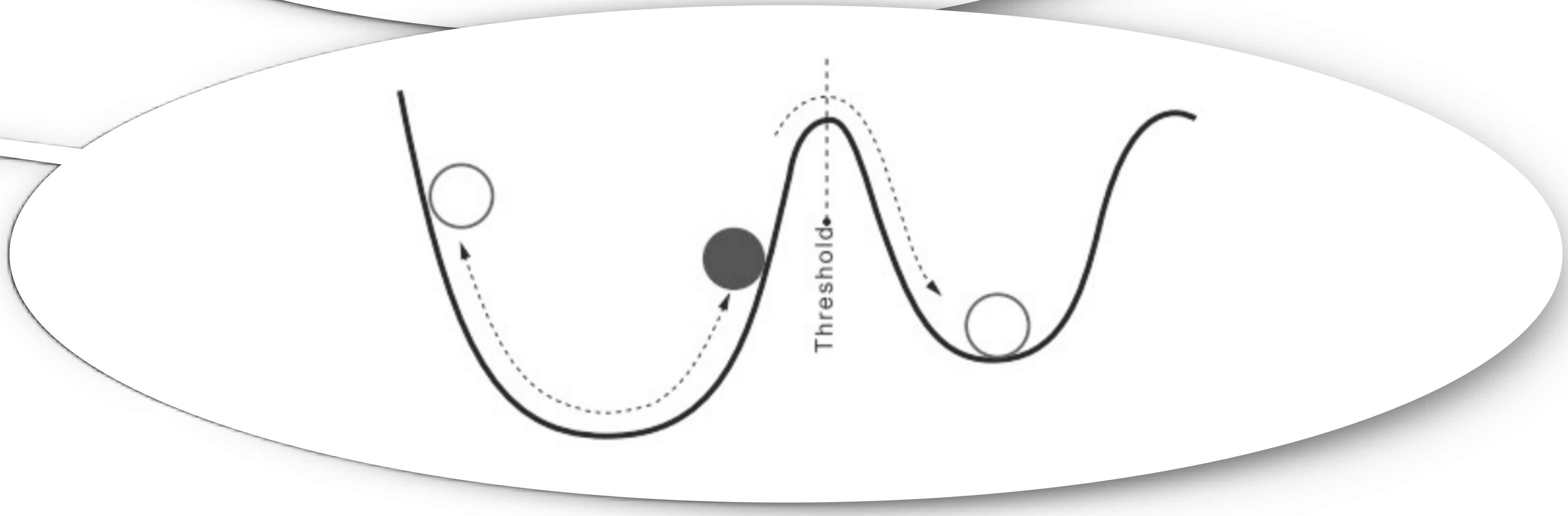

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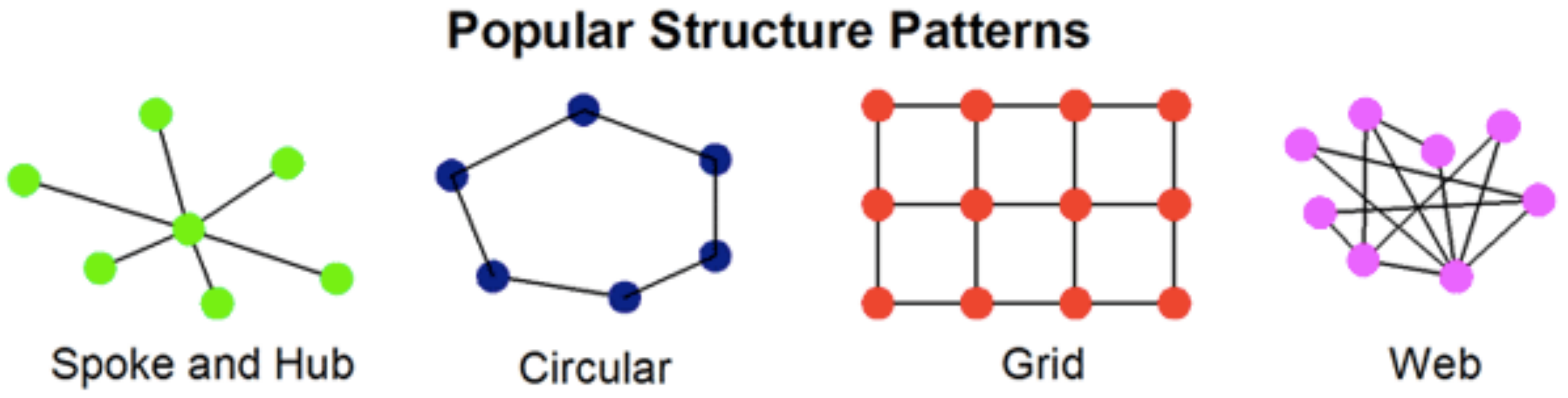

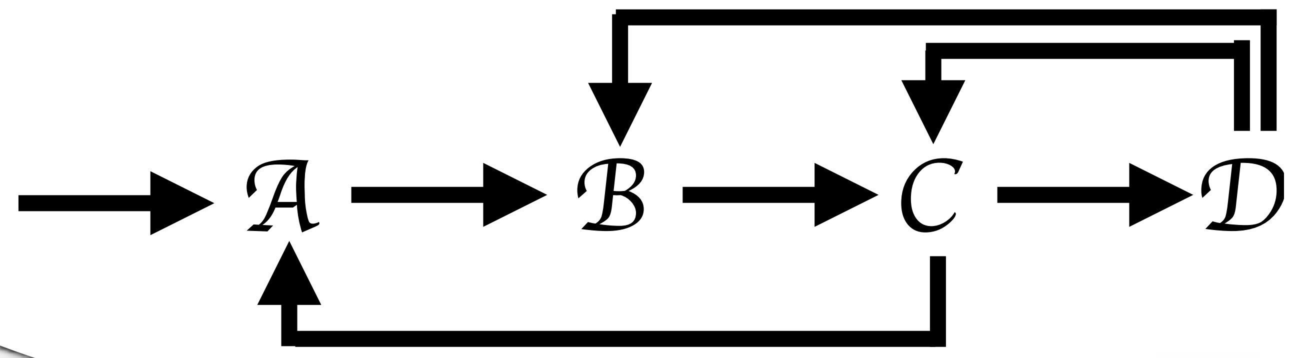

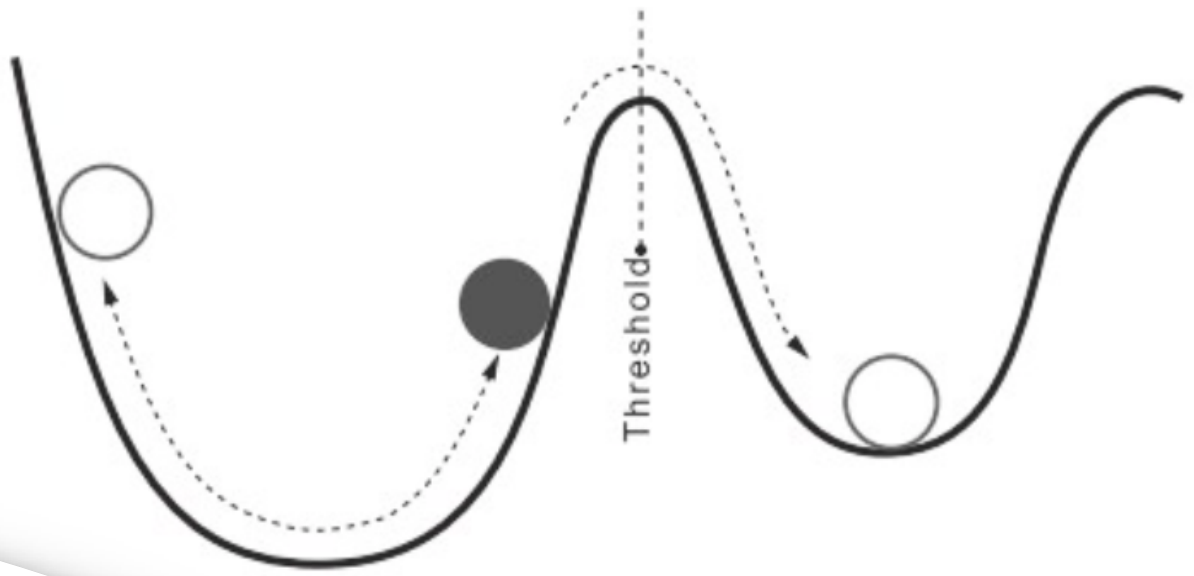

The threshold is not where the boat goes over the edge, it is far up the river, when the people in the boat lose the option to get to the shore.

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Complexity of a system expresses the degree to which components engage in organized structured interactions. High complexity is achieved through a mixture of order and disorder having a high capacity to generate emergent phenomena.

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Complexity of a system expresses the degree to which components engage in organized structured interactions. High complexity is achieved through a mixture of order and disorder having a high capacity to generate emergent phenomena.

A new field of science studying how parts of a system give rise to the collective behaviors of the system, and how the system interacts with its environment.

Social systems formed (in part) out of people, the brain formed out of neurons, molecules formed out of atoms, the weather formed out of air flows are all examples of complex systems.

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Dynamical systems: an ensemble of particles whose state varies over time and thus obeys differential equations involving time derivatives.

Prediction about the system's future behavior can be made based on an analytical solution of the equations or their integration over time (e.g., through computer simulations).

Dynamical systems can be used for approximations of "real-world" systems and subsystems.

If appropriate equations are not available, other approximations can be used to represent the dynamical system.

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Dissipative (structures) systems are nonequilibrium thermodynamic systems that generate order spontaneously by exchanging energy with their external environments. When the flow of energy and matter through them increases, they may go through new instabilities and transform themselves into new structures of increased complexity. Dissipative structures grow more complex by exporting, or dissipating, entropy into their environment. *Prigogine (1967)*

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A property which a (complex) system has, but which the individual members do not have.

A failure to realize that a property is emergent, or supervenient, leads to the fallacy of division.

The knowledge of the different types of emergence is essential if we want to understand and master complex systems in science and engineering, respectively

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Examples?