

# Complex Adaptive Systems

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# Researchers often refer to the following as “*Complex Adaptive Systems*”

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- ▣ Immune systems;
- ▣ Multi-cellular organisms;
- ▣ Insect colonies;
- ▣ Ecologies;
- ▣ Decentralized market economies;
- ▣ Robot “herds” (groups of robots interacting with each other in an environment).

**But what does this really mean?**

# Rough Definition of a Complex System

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- \* **Reference:** Sunny Auyang, "Synthetic Analysis of Complex Systems," available at "ACE Intro Materials" site at <https://www2.econ.iastate.edu/tesfatsi/aintro.htm>
- ▣ A **system** is any entity to be described.
- ▣ A **complex system** is a system that:
  - is composed of interacting units (components, primitive elements, constituents,...), and
  - exhibits *emergent* properties, i.e., properties arising from the interactions of the units that are not properties of the individual units themselves.

# Definition of a Complex System... Continued

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- Which (if any) of the following systems would you classify as a **complex system**?
  - ▣ A pencil?
  - ▣ A thermostat?
  - ▣ The Colorado River?
  - ▣ A labor market (i.e., a job market)?

# What about a *Complex Adaptive System*?

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**A range of possible definitions:** A *complex adaptive system (CAS)* is a complex system that contains at least some units that are...

**DEF 1:** *reactive*, i.e., they have an internal structure that reacts systematically to different environmental conditions.

**DEF 2:** *goal-directed*, i.e., they are reactive, and at least some of their reactions are directed towards achievement of goals.

**DEF 3:** *planners*, i.e, they are goal-directed and they attempt to exert some degree of control over their environment to facilitate achievement of these goals.

# Definition of CAS... Continued

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  - ▣ A thermostat?
  - ▣ The Colorado River?
  - ▣ A labor market (i.e., a job market)?