A Comparison of Three Neighboring Fields

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|  | **Cybernetics** | **Systems** | **Complexity** |
| Origin of the field | Macy Conferences, 1946-1953, American Society for Cybernetics founded, 1964 | An informal meeting within the 1954 meeting of the American Association for the Advancement of Science in Berkeley, California | 1984, Santa-Fe Institute founded (first meeting 1985) |
| Early authors | W. McCulloch, N. Wiener, A. Rosenblueth, M. Mead, G. Bateson, H. von Foerster, H. Maturana  | Ludwig von Bertalanffy, K.E. Boulding, Anatol Rapoport, James G. Miller, Ralph Gerard, Jay Forrester, Edwards Deming | M. Gell-Mann, G. West, R. Axtell, B. Arthur, J. Holland, S. Kauffman, S. Wolfram |
| Definition of field | Describe control and communication in animals, machines and social systems; create a science of purposeful systems  | Identify the common features of systems. A living system processes matter, energy, and information. It evolves over time and adapts to its environment | New entities and patterns of behavior emerge when many agents interact and adapt to each other and their environments |
| Purpose | Create a science of perception, regulation, learning, adaptation, goal formulation, and understanding | Create a general theory of systems and a variety of approaches to systems analysis | Identify the unseen mechanisms and processes that shape evolving worlds |
| Methods | Three fundamental models describe 1) regulation, 2) self-organization, and 3) reflexivity | Systems engineering, system dynamics,  causal loop diagrams, flow diagrams, process improvement methods | Rigorous logical, mathematical, computational methods |
| A key question | How does the brain understand the world and itself? How can we create self-governing societies? Howcan we create a reflexive science? | What are the structures and processes in living systems? What is essential for life? | How do order and novelty emerge in the world? |
| Internal mechanisms | Reflexivity operates on two levels – observing and participating | Miller's 19 critical subsystems -- e.g. input       transducer for information, ingestor for matter- energy, decoder, encoder, matter-energy  storage, reproducer, supporter, transporter, etc.; These processes occur on 8 levels: cell, organ, organism, group, organization, nation, supranational system, world | Increases in complexity require two processes: creating new variety and selecting appropriate variety; Describe the rules governing how agents interact |
| Locus of contribution | Extensions of philosophy | Share theories and methods for analyzing systems with other disciplines | Extensions of mathematics |
| How science advances | Expand the realm of inquiry by adding a new dimension |  Identify instances of processes such as evolution, adaptation, cognition | Find the underlying mechanisms of emergence  |
| Conception of Cognition | Cognition is one aspect of autopoiesis | Cognition is a perception and decision process in living systems | Cognition emerges in some biological processes |
| Conception of Complexity | Complexity lies in multiple conceptualizations of a system of interest which are created by people who have an interest in that system and its affect on the world | Complexity lies in the system observed | Complexity emerges in some systems as a result of the interactions among elements in the system |