Science as a Self-Organizing Meta-Information System

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Abstract

Four basic problems that a theory of science has to deal with concern epistemology, structure, causality, and dynamics of science. These problems deal with the relationship of induction/deduction, actors/structures, internal/external factors, and continuity/discontinuity. Traditionally they have been solved one-sidedly. Considering science as a self-organizing system allows a more integrative approach.
Science is a complex, nonlinear system that is made up of two moments: scientific actors and scientific structures. Scientific self-organization operates synchronously and diachronically. Synchronous scientific self-organization is a mutual production process between scientific actors and structures. Scientific systems are self-organizing units that perform the production of theories and truths by the way of a productive, circular causal duality of scientific actors and scientific structures. Science is a dynamic system where research practices produce and reproduce structures that produce and reproduce research practices. Scientific structures are medium and outcome of scientific actions. At the action level one can find a systemic hierarchy that is made up of individual researchers, research groups, scientific communities, and the overall scientific community. Scientific structures include theories, research institutions, technologies, journals, publications, science funds; norms, values, and rules of scientific conduct. The main scientific practices can be categorized as genuinely scientific practices (innovation, dissemination, scientific interchange, funding-related activities, teaching), cultural practices (public discourse), political practices (science policy), and economic practices (action related to scientific knowledge as commodities, patents, science-industry-partnerships, sponsorship).
Science is an open system that is structurally coupled to other subsystems of society, it is neither internally, nor externally determined, its development is caused by a complex interplay of internal and external factors, it is a relatively autonomous system. Systems in nature and society act as a sort of data for the scientific system, research processes establish an informational relationship between the scientific system and its environment in the sense that theories are complex, non-linear reflections of environmental processes. Due to the fact that all complex systems are informational, one can say that science produces information about information systems. Science is a 2nd order information system, it produces meta-information. Philosophy of science is a science of science, it produces information about information about information, it is a 3rd order information system. The metaphor of science as a grand hypertext refers to the self-referential character of scientific texts. A scientific text by the way of citation refers to other scientific texts, it incorporates part of the history of science, and methodologically discusses other texts.
The formation of scientific knowledge can be described as a double-process of induction and deduction, abstraction and concretization, where scientific knowledge consists of both empirical knowledge and theoretical knowledge and is formed in loop that consists of two self-organization processes. The self-organization of scientific knowledge is a mutually productive relationship between experience and theory. Scientific knowledge is a unity of experience and theory. The self-organization of scientific knowledge is a dialectical cycle where signals from material reality are transformed into experienced data that is interpreted and results in hypotheses and theories which are transformed into methods and technologies that are employed in order to cause effects in material reality that can again be observed as data. In this self-organization process there is the bottom-up-emergence of theoretical knowledge and the top-down-emergence of experiences and material effects.
Each scientific theory is a truth claim, but one that is based on a systematic methodology, permanent evaluation and correction, and conflict-based discourse. Hence scientific truths are not absolute truths, they are truths-in-

question, truths-in-discourse, and truths-in-conflict, and truths-in-development. One can distinguish formal, adequate, discursive, and practical truth of a theory. Due to the fact that the knowledge-based society is a high risk society, practical truth of science in the form of an ethically responsible science is of central importance. Diachronic self-organization of science means that dominant scientific paradigms at some point of time loose their effectiveness, paradoxes and instabilities show up, science enters crisis, a new dominant paradigm emerges. If a large gap between scientific theory and the problems posed for science by itself and by society emerges, the dominant structural patterns are increasingly questioned. This can have scientific or wider societal causes, or a combination of both. The resulting crisis is a process of creation and destruction. The whole process is one of the emergence of scientific order from noise. Variation is a permanent phenomenon of scientific evolution, but in phases of instability where the self-organization of science shifts from self-reproduction to order from noise the degree of variation and development by chance is much larger.

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