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## **Social metabolism and hybrid structures**

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What are the most promising (or necessary) directions for an integrated socio-environmental science capable of facing the challenges of sustainability? From our research experiences at the Institute of Social Ecology in Vienna, we believe there is a need for a new epistemological paradigm that allows the re-connection of the fields that have been separated in the course of the evolution of academic disciplines on both sides of the “great divide” (Snow 1959). This new paradigm can be sketched by the following general principles.

1. The qualitative differences between biophysical realities and the cultural/social/economic realm of meaning should be respected. In the latter, communicative interconnectedness reigns, rather than causal relationships. Merging the two realms on either side of the divide leads to a reductionism that will be rejected by the other intellectual tradition. Separation implies a mutual non-substitutability. Blindly transposing ideas from ecology or other natural sciences to social systems inevitably leads to fatal oversimplifications, of which perhaps the most famous example is Hardin's Tragedy of the Commons. Conversely, from the social domain, it is tempting to borrow ideas from natural sciences as metaphors, which too often only serve to creatively obscure reality. A truly integrated social and environmental science requires openness and a healthy dose of scepticism: ideas and concepts should be tested, contrasted, pitted against each other, so that new, better ideas and paradigms can emerge. Complexity should be acknowledged without being fetishized.
2. Maintain a thorough understanding of the grand biogeochemical cycles and the various types of physical interdependencies they imply. We know that biogeochemical cycles are connected but in no way substitutable, but this understanding needs to become foundational to our integrated science in order to avoid simple mistakes with profound implications, such as the notion that biofuels can substitute fossil fuels, or that hectares are an appropriate way to measure carbon emissions. Taking stock of interdependency and non-substitutability requires moving beyond simple air-soil-water categorizations, the ecosystem level, and also beyond single sectors of the economy. Grand cycles remind us to transcend territorial boundaries, and include globalization and trade in our analysis. The biogeochemical cycles and their anthropological perturbations are the evidence of an integrated earth, and it is imperative that our science rise to the task of explaining the interconnected social and cultural activities which have such global implications.
3. Respect the diversity of geographic locations and scales, while avoiding the pitfall of local studies which discourage the detection of larger patterns. Recognize the decisive role of interconnectedness between regions. Interconnectedness occurs through trade, migration, communication, and, crucially, through history, as well as through the grand cycles mentioned above.
4. Respect the directionality of time and the system-specificity of time horizons. Deal with path dependencies and long term effects in both directions (sustainability is a long term issue – and it has been for many societies before). Be prepared to learn from longer time horizons than the post WWII era, not just in terms of environmental challenges, but also social upheavals.

5. Focus on hybrid structures (Latour 1993) as mediating between the two realms, and as mediating between past and future across time. Hybrid structures are structures moulded both physically and culturally, structures in which the rules of the two realms are somehow superimposed upon one another. Such hybrid structures are for example technologies, infrastructures, physical stocks of social systems; in our view, these also encompass the human population. Traditional sciences, both natural science and the humanities, cannot appropriately deal with such hybrid structures: they perceive only one aspect and cannot recognize the other. These hybrid structures have to be reproduced both culturally/socially/economically and physically. This is where the notion of social metabolism takes hold: as socially governed physical flows that are required to reproduce society's hybrid structures. Future research directions should identify sustainable societal directions through their hybrid structures, but also explicitly deal with the legacy of current hybrid structures, which will continue to influence society and the environment far into the future.
6. Be aware of the autopoietic character of economic cycles: in the end, money will buy you physical objects (or set in motion physical work). And in the end, efficiency will not buy you physical resource savings, but instead drive growth (Ayres and Warr 2009, Polimeni et al. 2008).
7. Pay attention to human population, its size, demographic structure and wellbeing. This should be obvious, but is too often forgotten in favour of economically-focused analyses. The economy's function is symbolic valuation and prioritisation, and is not fully-disconnected from human wellbeing, but studying human wellbeing should be a separate, and possibly more important, sustainability research focus. An integrated sustainability science should be informed by the fields of demography and public health, and grapple with the issue of defining a fulfilling, meaningful life, given the diversity of human experience and potential. In this sense, sustainability science can be seen as a successor to the enlightenment, moving the question of human existence on earth away from catastrophist, moral/religious extremism and the economic ideology of endless plunder to a more balanced, equitable and, above all, more reasonable relation with each other and our environment.

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