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Co-Evolution of Structure, Heterogeneity, and Function During Pedogenesis

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Besides roots and earthworms, microorganisms play a fundamental role in the formation, stabilization, and turnover of “structure” in natural soil. While the former two are also important “bioturbators”, the role of microorganisms evolves from their particle enmeshment (e.g., fungal hyphae) and colonization and alteration of the fluid exposed surfaces in soil, the biogeochemical interfaces. The interdependences and feedbacks of soil structure dynamics and the activity of soil biota affect the fluid flow and the transport of matter and information in dynamic ways by altering the spatial assignment of soil materials, but also by changing their mechanical and surface properties as well as the hydraulic and pneumatic characteristics of the dynamics void-network system. These alterations and structural reorganizations occur at spatial scales already at the submicron scales with yet far-reaching consequences for soil functions at the pedon scale and beyond. Understanding the coevolution of structure and heterogeneity and the insight to which extent this coevolution impacts soil properties and functions is progressively evolving, allowing unraveling of their implications for soil quality and the soil-based ecosystem services. This presentation compiles the current understanding of the interplay of abiotic and biotic forcings for structural dynamics and its consequences on the processes and functions in soils. It builds on synthesizing the evidence, findings, and outcomes of field surveys, computer simulations, and experimental pedogenesis.