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Plant silicon and phytoliths: Ecology, evolution and the Earth-life superdiscipline

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Despite the considerable advances in the studies of plant silicon and phytoliths and their formation, function and cycling, our understanding of the role plant silicon and phytoliths play in ecosystem ecology, global ecology and organismal evolution is relatively limited. This is in part because our knowledge is still very much based on studies of silicon-rich grasses and/or on studies that seldom directly address evolutionary questions. The few studies that have looked beyond grasses and into evolutionary questions reveal a complex ecological and evolutionary reality.

The issue of plant silicon and phytolith roles as antiherbivory defences is a striking example. Despite many laboratory and field studies in grasses, comparable studies of non-grasses are rare. Recent studies have shown that patterns in phytolith contents variations along climatic gradients that are related to plant defence theories were found to commonly apply for grasses, but much less so for non-grasses. This implies that the antiherbivory roles that phytoliths are known to play in grasses are probably of lesser extent and significance in non-grasses. Thus, the ecological roles of plant silicon in grasses and non-grasses may vary considerably.

Furthermore, phylogenetic analyses of the distribution of plant silicon accumulators suggest multiple origins of the trait that do not seem to temporally coalesce with abiotic or biotic stimuli. However, when shifting the view from times of origin to times of diversification, a possible link appears with the evolution of abrasion-adapted dentition in some dinosaur groups. While this coalescence suggests direct coevolution of plants and herbivores, it may also be that herbivores that were better adapted to silicon-rich plant foods have accelerated silicon cycling and made silicon more available to the plants that could utilise it better.

Finally, there is increasing body of evidence that plant silicon contents trade-off with the contents of various carbon-based compounds (e.g., lignin and phenolics). Since silicon can sometimes play comparable roles to those carbon-based compounds, it is possible that silicon is a partial substitute for carbon. To this we should add that silicon uptake by plants affects the carbon cycle through various biological, geochemical and atmospheric processes. It is not surprising then that some of the most productive terrestrial ecosystems are dominated by silicon-rich species. However, a unified model for silicon effects on the carbon cycle is missing.

Such studies broaden the scopes of plant silicon and phytolith research and can considerably contribute to our understanding of how this trait shapes and has shaped ecosystems and Earth systems. By doing so, plant silicon and phytolith research demonstrates the potential power of merging Earth and life sciences into one superdiscipline, a pivotal current process in which this unique field can lead the way.