Plants are 'biting' back: Scientist discover 'teeth' on plants of the rock nettle family

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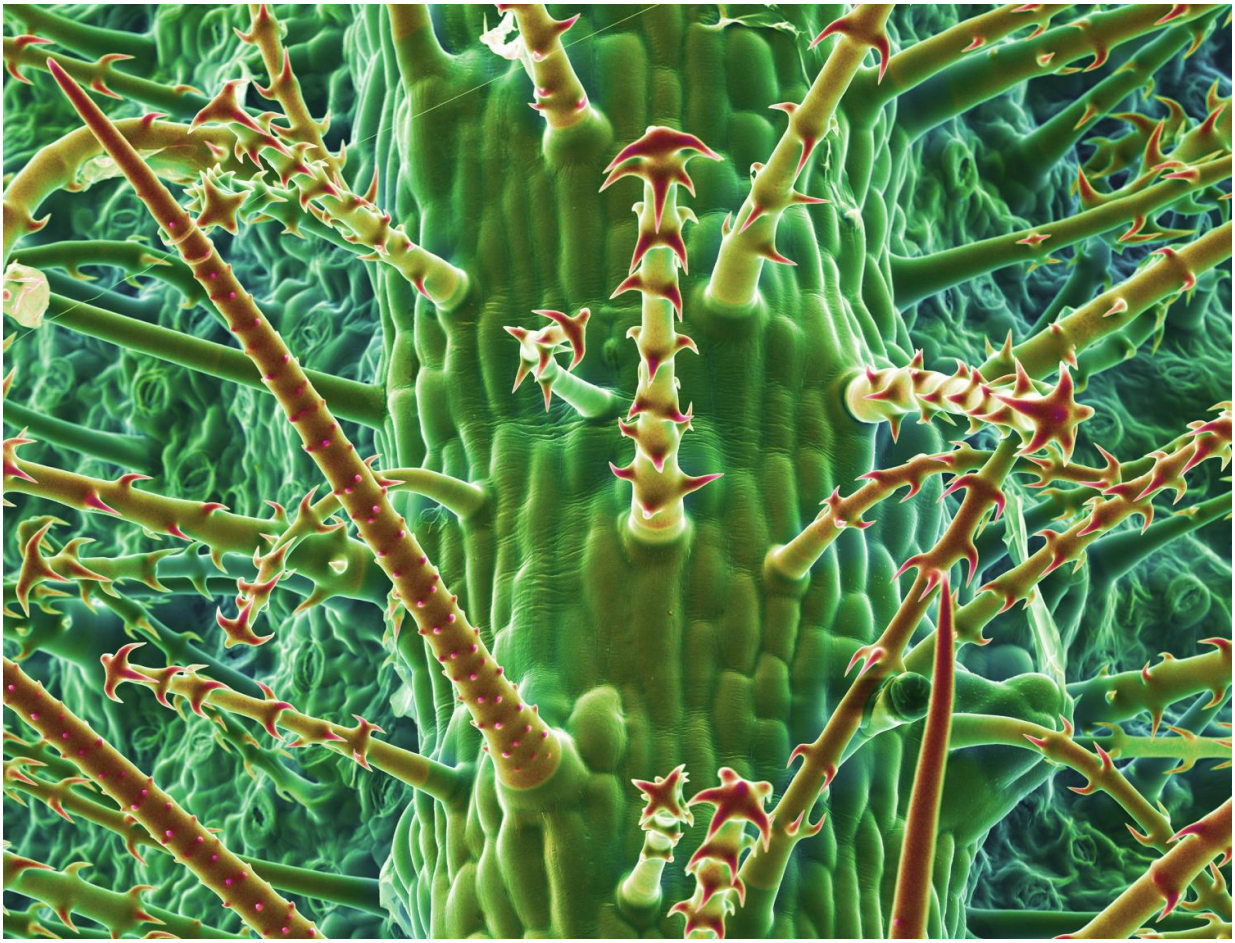

Detail of the lower leaf surface of Loasa pallida. The red areas are mineralized (here not differentiated between different minerals). Credit: (c) Image: H.-J. Ensikat und M. Weigend/Uni Bonn

Calcium phosphate is a widespread biomineral in the animal kingdom: Bones and teeth largely consist of this very tough mineral substance. Researchers from Bonn University could now for the first time demonstrate the presence of calcium phosphate as a structural biomineral in higher plants. The substance provides the necessary "bite" to the stinging hairs of representatives of the rock nettle family (Loasaceae). It hardens the trichomes, which serve as a herbivore defense. Conversely, our native stinging nettles have stinging hairs hardened by glass-like silica. The results of the study are now published in the journal *Scientific Reports*.

Animals only eat them once: When the tongue touches the minute trichomes of rock nettles (Loasaceae), the tips of the stinging hairs break off and a painful cocktail pours out into the sensitive tissue. These well-defended plants have their centre of diversity in the South American Andes. "The mechanism is very similar to that of our well-known stinging nettles", says Prof. Dr. Maximilian Weigend of the Nees-Institut for Biodiversity of Plants at Bonn University. There are additional differences between the only stinging nettles and rock nettles—which are only distantly related—apart from their different appearance: Native stinging nettles fortify their needle-like hairs with silica, while their spectacularly flowering South American counterparts employ calcium phosphate for that purpose.

Calcium phosphate has never previously been documented as a structural biomineral in higher plants. "The mineral composition of the stinging hairs is very smilar to that of human or animal teeth" says Prof. Weigend, who has been researching the highly diverse rock nettles for the past 25 years. Many scientists previously noted the strikingly rough hairs of this plant group, but nobody ended up researching their chemical composition. The botanists investigated the stinging hairs—built like hypodermic syringes—with their own electron microscope and in collaboration with colleagues from the Steinmann-Institute for Geology,

Mineralogy and Paleontology and the Institute of Inorganic Chemistry of Bonn University.

A picture of the rock nettle *Blumenbachia insignis* in the Botanical Gardens of Bonn University. Credit: (c) Photo: M. Weigend/Uni Bonn

Tips of the stinging hairs structurally similar to reinforced concrete

It could be shown that especially the mechanically highly stressed tips of the hairs are incrusted with calcium phosphate. "This is essentially a composite material, structurally similar to reinforced concrete", explains Prof. Weigend. The fibrous cellulose as the typical material of plant cell walls provides the scaffolding and is densely incrusted with tiny crystals

of calcium phosphate. The scientist of Bonn University is convinced "This renders the stinging hairs unusually rigid".

It is still unclear why rock nettles evolved this particular type of biomineralization, while most plants use silica or calcium carbonate as structural biominerals. "A common reason for any given solutions in evolution is that an organism possesses or lacks a particular metabolic pathway", says Prof. Weigend. However, rock nettles are able metabolize silica and use it as a structural biomineral—side by side with calcium phosphate. It is not currently understood why it is particularly calcium phosphate that is used in the stinging hairs tips, the very substance that the mouthparts of their enemies also consist of. "At present we can only speculate about the adaptive reasons for this. But it seems that rock nettles pay back in kind - a tooth for a tooth" chuckles the biologist of Bonn University.

Blumenbachia insignis. Note the long, mineralized stinging trichomes, especially on the young fruit, but also on the perianth. Credit: (c) Photo: M. Weigend/Uni Bonn

Bionics: plant trichomes as templates for bone substitutes

Additional research projects are directed towards investigating which other plants may use structural calcium phosphate to face challenges in their natural environment and which biomechanical advantages this material conveys to the plants. The discovery is also of potential relevance for bionic applications. "Surgical bone substitutes have to be highly tissue compatible, cellulose-composite are likely to meet that criterion", says Prof. Weigend. First attempts at producing artificial cellulose-calcium phosphate composite have been made by other researchers, but so far a natural template was unknown. The cellulose-calcium phosphate composite in rock nettles could be just such a template.

More information: Hans-Jürgen Ensikat, Thorsten Geisler & Maximilian Weigend: A first report of hydroxylated apatite as structural biomineral in Loasaceae - plants' teeth against herbivoren, *Scientific Reports*, DOI: 10.1038/srep26073

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