Scientists analyze branch patterns in trees and art, from da Vinci to Mondrian

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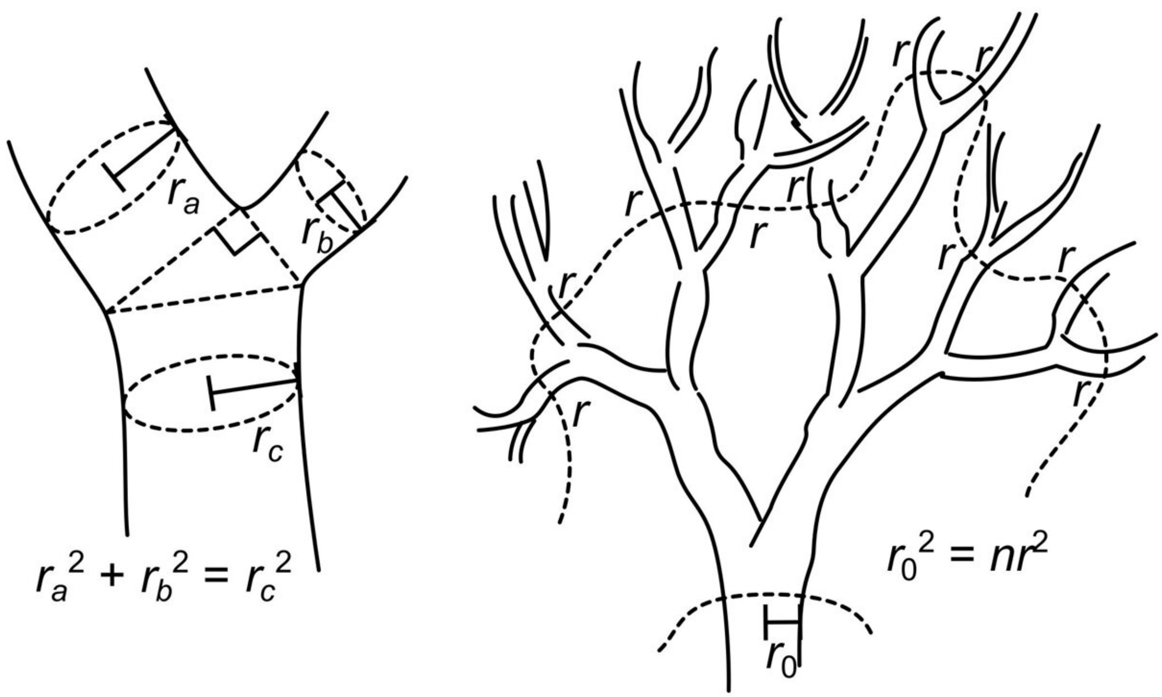
Blossoming apple tree, by Piet Mondriaan, 1912. Credit: Kunstmuseum Den Haag

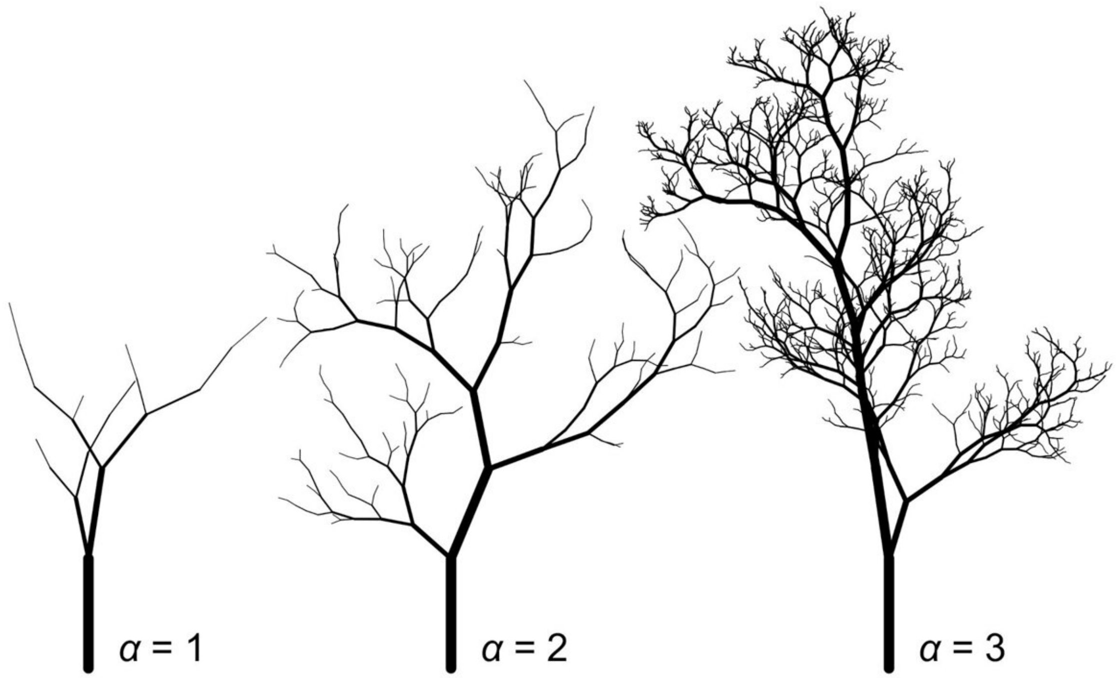
The math that describes the branching pattern of trees in nature also holds for trees depicted in art—and may even underlie our ability to recognize artworks as depictions of trees.

Trees are loosely fractal, branching forms that repeat the same patterns at smaller and smaller scales from trunk to branch tip. Jingyi Gao and Mitchell Newberry examine scaling of branch thickness in depictions of trees and derive mathematical rules for proportions among branch diameters and for the approximate number of branches of different diameters. The work is published in *PNAS Nexus*.

The authors begin with Leonardo da Vinci's observation that trees limbs preserve their thickness as they branch. The parameter α, known as the radius scaling exponent in self-similar branching, determines the relationships between the diameters of the various branches.



Combined cross-sectional area (πr2) is preserved across branching. The tree on the right uses such transects to count the number of branches n that have radius approximately r to derive a fractal scaling relationship. Credit: Jingyi Gao and Mitchell Newberry



Three trees generated by the same random algorithm differ only in the value of α used to compute the branch diameters. The algorithm stops adding branches when the radius reaches roughly 1/10th that of the trunk, creating exponentially more branches for higher values of α. Credit: Jingyi Gao and Mitchell Newberry

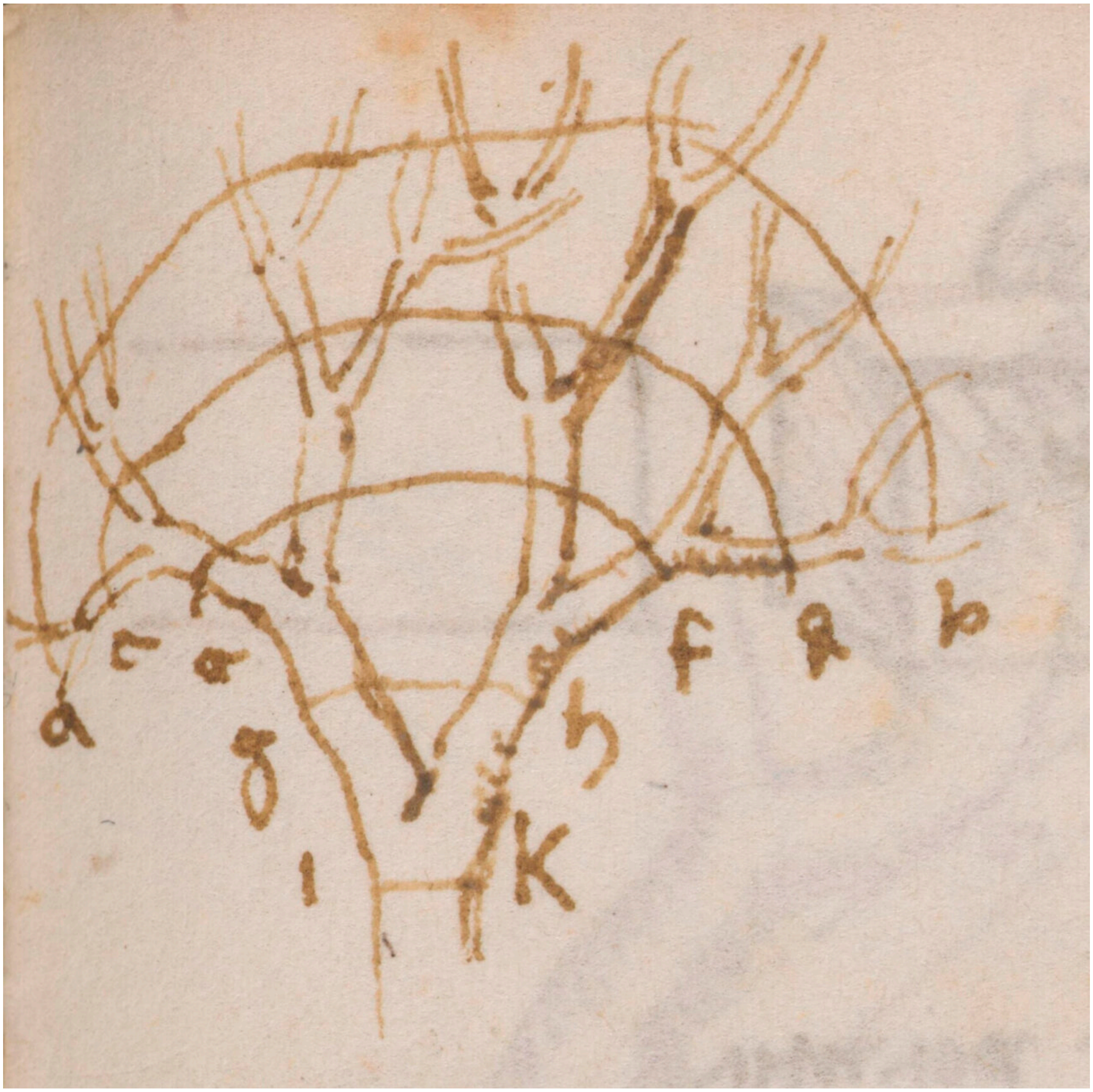
If the thickness of a branch is always the same as the summed thickness of the two smaller branches, as da Vinci asserts, then the parameter α would be 2.

The authors surveyed trees in art, selected to cover a broad geographical range and also for their subjective beauty, and found values from 1.5 to

2.8, which correspond to the range of natural trees.

Even abstract works of art that don't visually show branch junctions or treelike colors, such as Piet Mondrian's cubist Gray Tree, can be visually identified as trees if a realistic value for α is used. By contrast, Mondrian's later painting, Blooming Apple Tree, which sets aside scaling in branch diameter, is not recognizable as a tree.

According to the authors, art and science provide complementary lenses on the natural and human worlds.



Leonardo da Vinci's sketch of a tree illustrates the principle that combined thickness is preserved at different stages of ramification. Credit: Institut de France Manuscript M, p. 78v.

Gray Tree, by Piet Mondrian, 1911. Credit: Gemeentemuseum Den Haag

More information: Jingyi Gao et al. Scaling in branch thickness and the fractal aesthetics of trees, *PNAS Nexus* (2025). DOI: 10.1093/pnasnexus/pgaf003. academic.oup.com/pnasnexus/art … 93/pnasnexus/pgaf003

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