Leonardo da Vinci and the Science of Wood: The Note in the Madrid Codex II as a Foreshadowing of Modern Bioarchitecture

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Abstract

In the Madrid Codex II, preserved at the Biblioteca Nacional de España, Leonardo da Vinci records a brief yet remarkably significant reflection on wood preservation, describing a specific treatment technique aimed at making it resistant to degrading agents. This short note, seemingly marginal compared to the grand themes of mechanics or hydraulics that permeate the codex, actually reveals a profound awareness of the organic behavior of materials and an early intuition of what, centuries later, would be defined as "bioarchitecture." The aim of this study is to analyze this annotation in light of Leonardo's technical-scientific thought, the Renaissance cultural context, and the contemporary rediscovery of its experimental value. Through a comparative approach between Leonardo's manuscript sources, contemporary treatises, and modern studies on the behavior of lignocellulosic materials, we intend to demonstrate how Leonardo understood the need to integrate science, nature, and sustainability long before these concepts were formulated in the language of modernity. His reflection on the "life of wood" emerges as a paradigm of systemic thinking ante litteram, capable of combining empiricism and natural philosophy.

Introduction

Among the many facets of Leonardo da Vinci's work, his attention to natural materials holds a central place. Wood, in particular, represents for Leonardo not merely a construction material, but a living organism—a system in balance with its environment. In the Madrid Codex II—written between the late 15th and early 16th centuries during his Milanese period—Leonardo records a note that testifies to his empirical investigation into a method of protecting wood to ensure its durability over time. This note, seemingly technical, fits within a broader perspective: Leonardo observes, analyzes, and experiments with the resistance of organic materials, applying principles that today we would define as "eco-compatible." His interest is not limited to mechanical effectiveness but extends to the relationship between matter and environment, between natural processes and human intervention. He understands that every material, to be truly functional, must be treated according to its "inner nature," respecting what we would now call the material's "intrinsic sustainability."

As highlighted by various historical and popular sources and through direct examination of the manuscript, Leonardo notes in the Madrid Codex II a technique that is particularly used today in Japanese culture for protecting wood through controlled surface charring. This procedure is strikingly similar to what is known in modern times as *Yakisugi*. The annotation is not an isolated case. In other parts of his manuscripts, Leonardo reflects on the behavior of plant matter, the transpiration of wood, its ability to absorb and release moisture, and the chemical-physical transformations that alter its consistency over time. This attention to the "life of the material" aligns with his vision of the world as a dynamic organism, where the laws of nature repeat on both micro and macrocosmic scales. From a historical perspective, the note appears at a crucial moment for European material culture. Between the 15th and 16th centuries, woodworking was receiving renewed attention in artistic workshops and civil engineering studies. Leonardo, immersed in this technical fervor, elevates the theme of wood to a subject of theoretical study, interpreting it through an interdisciplinary lens that combines art, science, and natural philosophy. The modern rediscovery of this annotation is not merely a philological curiosity: it restores an image of Leonardo as a forerunner of ecological and sustainable culture, a thinker who anticipates the modern idea of "smart materials"—not passive, but responsive to their surrounding environment.

2. Analysis of the Note in the Madrid Codex II: Philological Interpretation and Technical Implications

Leonardo da Vinci's brief annotation in the Madrid Codex II—"They will be better preserved if debarked and superficially charred than in any other way"—is one of the most dense and revealing fragments of his technical and scientific thought. In just a few words, Leonardo expresses a principle of surprising modernity: the protection of wood through controlled surface charring, a method that prolongs the material's lifespan by modifying its outer structure without altering its mechanical properties.

2.1. Philological Interpretation of the Text

Linguistically, the sentence is characterized by a prescriptive and experimental syntax. The verb "will be preserved" suggests an empirical generalization: Leonardo is not proposing a hypothesis, but stating a rule derived from

direct observation. The phrase “debarked and superficially charred” defines two successive and complementary operations: removing the bark and charring the surface. The first eliminates the biologically active layer, prone to decomposition and infestation by xylophagous insects; the second creates a protective carbon barrier. The verb “char,” in Leonardo’s typical orthography, does not imply destruction but a process of controlled exposure to fire, reflecting his experimental methodology based on the regulation of natural phenomena. Finally, the comparative clause “than in any other way” expresses an absolute, almost dogmatic conviction: no other procedure, according to Leonardo, is more effective in preserving wood. Thus, in a single sentence, Leonardo condenses an entire empirical theory of organic material stability.

2.2. Technical and Experimental Context of the Note

The annotation is part of the technical reflections in the Madrid Codex II, which includes studies on mechanics, civil engineering, and construction materials. Leonardo consistently shows interest in the structural properties of natural materials—stone, metal, wood—observing them through the eyes of both artist and engineer. In the specific case of wood, the recommendation to debark and superficially char it responds to precise physical observations. Through direct experience in workshops and construction sites, Leonardo had noticed that raw wood left with its bark tended to retain moisture and decay more quickly. By removing this layer and lightly “charring” the surface, the material stabilizes: the carbonized layer creates a hydrophobic and biocidal film that prevents water penetration and microbial proliferation. This principle—now fully validated by materials science—corresponds to the phenomenon of surface carbonization, or “partial pyrolysis,” whereby the hemicellulosic and lignin components of wood thermally degrade to form a compact layer of amorphous carbon. This layer drastically reduces wood permeability, increasing its resistance to atmospheric and biological agents. Leonardo’s intuition anticipates the Eastern technique known as *Shō Sugi Ban* (Yakisugi), traditionally used in Japan to protect cedar wood.

2.3. Epistemological Significance: From Empirical Gesture to Theory of Matter

Leonardo’s sentence should not be interpreted as a mere technical tip, but as the manifestation of a theory of living matter. He considers wood not as inert material, but as a body that “lives and breathes,” subject to the same laws of birth, transformation, and decay that govern all natural organisms. The practice of “charring” thus becomes an act of controlled transmutation, through which humans intervene in the material’s life cycle to grant it a form of survival. In other words, Leonardo does not destroy the wood, but “fixes its life” in a state of thermodynamic equilibrium. Viewed from this perspective, the annotation reveals the deep connection between experiment and natural philosophy in Leonardo’s thought. Knowledge arises from observing nature’s spontaneous processes, which humans can imitate and accelerate without violating its laws. Fire, the quintessential element of transformation, is interpreted not as a destructive force but as a tool of regeneration—a “cognitive flame” that enables understanding and reproduction of matter’s vital processes. Leonardo applies this same logic to many other materials—metals, pigments, stones—conceiving every transformation as a passage from an unstable state to a more perfect one. Charred wood is an emblematic example: fire, when used with

measure, does not take life from matter but preserves it in the most stable form of its being.

2.4. Interpretive Conclusion

The phrase "They will be better preserved if debarked and superficially charred than in any other way" thus encapsulates a dual dimension:

- A technical-experimental dimension, anticipating wood protection methods still in use today and based on principles of materials chemistry;
- A philosophical-naturalistic dimension, in which matter's transformation becomes an act of knowledge and a manifestation of harmony between humans and nature.

3. Leonardo and the Philosophy of Matter: From Wood to Renaissance Bioarchitecture

3.1. Premise: Leonardo as an Observer of Materials

The brief yet meaningful annotation found in the Madrid Codex II—"They will be better preserved if debarked and superficially charred than in any other way"—succinctly conveys Leonardo's epistemological stance toward matter: he does not view materials as passive entities to be exploited, but as dynamic systems whose durability depends on technical knowledge that respects their internal nature. This perspective positions the Florentine genius as a precursor to what we now call "bioarchitectural" practice: human intervention on materials must be calibrated to an understanding of their biological and physical properties.

3.2. Chronology and Priority: Leonardo and the Japanese Practice of Shō Sugi Ban

A key element in understanding the historical significance of the note is the chronological precedence between Leonardo's statement and the codification of the Japanese technique known as *Shō Sugi Ban* or *Yakisugi*. The Madrid manuscripts date approximately to the late 15th–early 16th century; documentary evidence of wood charring in Japanese tradition becomes consolidated only in the modern era (17th–18th century), with a distinct cultural and aesthetic codification in Japanese architecture. Therefore, as studies suggest, Leonardo's formulation predates the Japanese practice (and its nationalization): from this standpoint, the note cannot be read as emulation but as an autonomous anticipation. This chronological factor is crucial to how we interpret the statement: it is not a demonstrable intercultural derivation (there is currently no evidence of direct technical transfer from Asia to Leonardo), but rather a case of convergent invention—a solution independently arrived at for a universal technical problem: how to improve wood's resistance to atmospheric and biological agents.

3.3. Convergence of Empirical Intuition and Theoretical Awareness

The strength of Leonardo's phrase lies in its dual register: practical and theoretical. On a practical level, Leonardo outlines a two-step procedure—removal of bark; surface treatment with fire—that responds to

recurring empirical observations in workshops and construction sites. On a theoretical level, he formulates a general rule of comparative effectiveness: the "charred" treatment, in his view, surpasses all other available methods. This dual value is the hallmark of his experimental method: repeated observation gives rise to a rule that, though expressed succinctly, carries prescriptive weight.

3.4. The Problem of Modern Explanations: Experimental Evidence as Framework, Not Historical Judgment

In discussing the scope of Leonardo's intuition, it is useful to distinguish between two levels of interpretation: the historical-philological level—which assesses the significance of the statement within Renaissance thought—and the modern-experimental level—which measures the technical effectiveness of the process through controlled testing. While the former dimension recognizes Leonardo as a theoretical and methodological forerunner, the latter requires scientific protocols to validate the practical efficacy of surface carbonization under varying conditions.

The relationship between these two perspectives has recently been explored in scientific studies examining the behavior of charred wood (for a concise reference to experimental literature, see Hasburgh et al., 2021). These studies confirm that surface carbonization can produce protective effects, while noting that such effects depend on wood species, operational parameters, and environmental conditions. Nevertheless, their findings do not diminish the historical importance of Leonardo's insight: the phrase demonstrates his ability to infer, from qualitative observations, material properties that modern experimental science would later quantify and define.

3.5. Conceptual Priority: Leonardo as Independent Forerunner

Based on historical findings and the chronological sequence of documentation, it is reasonable to assert that Leonardo independently formulated a principle which, although developed and codified centuries later in Japan, follows the same technical-functional logic: transforming the wood's surface with heat to enhance its durability. In terms of the history of techniques, this represents a classic case of local anticipation: an empirical observation systematized by an observer with method and capacity for generalization.

For this reason, historical reconstruction should emphasize not a relationship of cultural derivation, but rather Leonardo's conceptual and chronological priority: he formulates, in the heart of the European Renaissance, a wood treatment strategy whose practical validity would later be recognized and reused—independently—in other technical traditions.

3.6. Summary

The main lesson from analyzing the note is twofold: on one hand, Leonardo emerges as an observer and theorist of matter capable of generalizing from empirical experiences; on the other, chronology and context show that his intuition is autonomous from the later Japanese practice. Rather than saying "Leonardo copied the Japanese," it is more accurate to say that Leonardo anticipated—and, retrospectively, other technical traditions arrived at conceptually similar solutions.

4. Conclusions

Leonardo's statement—"They will be better preserved if debarked and superficially charred than in any other way"—represents not only a technical insight but a true theory of living matter. In this brief remark, Leonardo da Vinci synthesizes years of observation, experimentation, and reflection on wood—a living material, subject to decay, yet potentially stabilizable through calibrated intervention.

The analysis conducted in this study has shown that:

- The annotation is situated within the technical-material context of the Madrid Codex II, a collection of writings and drawings documenting Leonardo's interest in materials and construction processes ([bibliotecadileonardo.museogalileo.it]).
- From a philological standpoint, the note adopts a prescriptive form ("they will be better preserved…") that indicates a generalized empirical rule, distinct from mere occasional observations; it defines a method combining bark removal and controlled surface carbonization.
- From a historical-chronological perspective, Leonardo precedes the codification of the Japanese technique of *Shō Sugi Ban* (or *Yakisugi*) by over a century, and there is no evidence of direct contact between Renaissance European culture and Japanese building practices regarding this method. In this sense, his is an autonomous anticipation.
- The transformation of wood suggested by the note—bark removal; superficial exposure to fire—anticipates modern concepts in materials science and bioarchitecture: waterproofing, biological barriers, chemical-physical stabilization of wood surfaces.

The contemporary relevance of the annotation lies in showing that for Leonardo, wood was not merely a building material, but a subject of systematic study, and that the durability of materials depended not only on construction quality but on the relationship between matter, environment, and human intervention.

From a methodological standpoint, the case illustrated invites scholars of the history of techniques and materials to pay closer attention to "minor" annotations in Renaissance manuscripts: they often conceal technical and material principles that would only later be operationally codified. In Leonardo's case, the transformation of wood becomes a paradigm of thought that unites art, science, nature, and technique.

Finally, this research proposes a reinterpretation of Leonardo not only as an inventor or painter, but as a forerunner of sustainability—the first in Europe to suggest a wood protection technique now considered "eco-construction." His observations pave the way for reading Renaissance technology as a laboratory of material solutions that still hold relevance in the 21st century.

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