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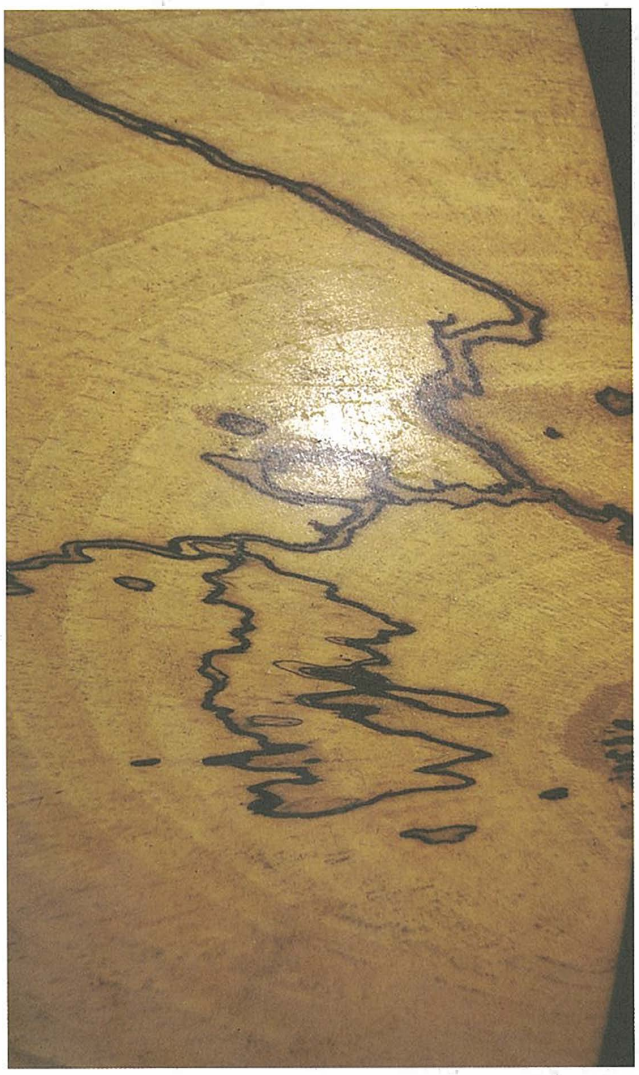
Spalted wood and the dark si

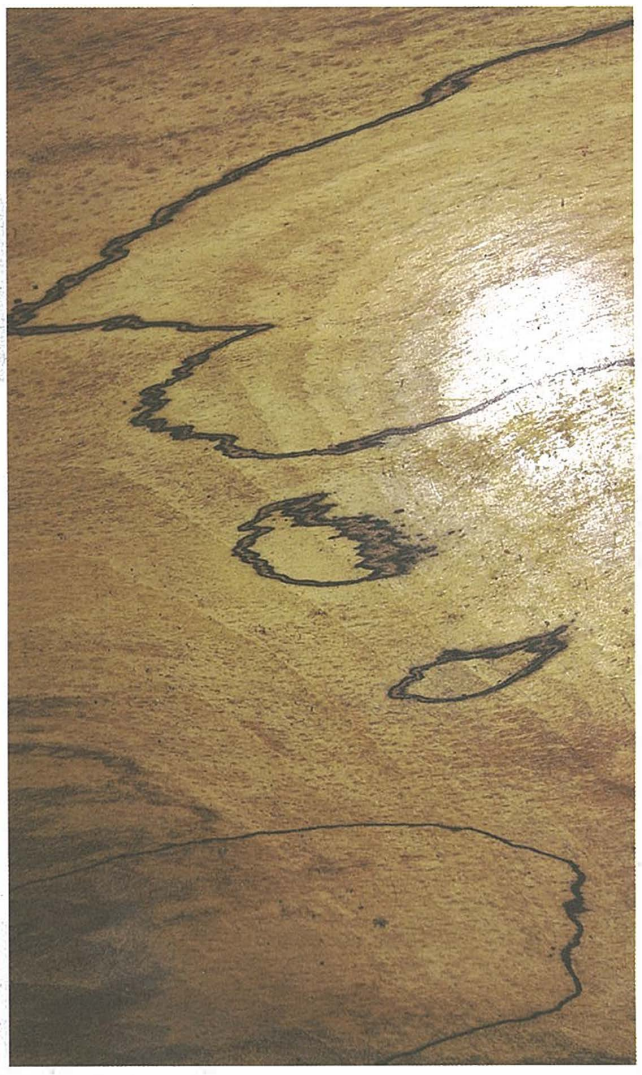
Many scientists, past and present, have sought to combine science with art, and vice versa. Leonardo da Vinci took a scientific approach to his art, where his application of geometry was exercised to great effect, shaping how he viewed the world and thus shaping his art. For Leonardo, precision was the key. Edward O. Wilson, known for his outstanding work on ants, said, "The love of complexity without reductionism makes art; the love of complexity with reductionism makes science", in Consilience: the unity of knowledge. Art and science are inseparable, and it is a great privilege as a scientist to be able to apply the scientific method to meet artistic ends. A botanist by trade, I turned to fungi to investigate fungal-wood interactions and attempt to manipulate fungi, enabling the creation of unique patterns in wood, a term referred to as spalting. This is being achieved at the Laboratory for Applied Wood Materials, Empa-Swiss Federal Laboratories for Materials Testing and Research, an affiliate of ETH Zurich, in collaboration with our industrial partner, Koster AG. The project is under the supervision of the revered forest pathologist, Prof. Dr. Francis Schwarze. Francis is most well-known for developing a fungal-induced violin with acoustics matching and even surpassing that of the great Stradivarius violins, a separate project progressing alongside my own.

Spalting is a term specifically designated to any pattern in wood caused by a fungus, and occurs naturally in wood as a result of competition between fungal species and often between strains of the same species, or when fungi interact with living parenchymatous cells.

All wood can spalt but not all fungi cause spalting. Spalting comes in two forms, pigmentation and zone line formation. The former is caused by ascomycetous fungi that seek the free sugars available in living cells, while the latter is related to ascomycetous and basidiomycetous fungi that break down the building blocks of dead wood cells. While pigmentation is evident through a range of spectacular hues in wood from greens to yellows, blues and reds, zone lines are depicted by sharp narrow black three-dimensional lines. I am focussing on the latter in order to meet the increasing demands for natural wood material with aesthetic character in the high-end furniture market.

Spalted wood holds a unique position in the history of art. The discovery of blue-green wood in the 15th Century, meant many great works of art were made using this material during this time and these can be found in museums across Europe, especially in Austria and Germany. Zone lines, however, were first formally discovered much later in 1878 by Robert Hartig, the great German Forest Pathologist, but the cause remained elusive until 1933 when the mycologist Alex Campbell made attempts to understand the cause, concluding that they were the result of antagonism between competing decay-causing fungi. The black lines are in fact made of melanin, which is produced by specialised cells of decay-causing fungi. Melanin is the same substance produced in humans in response to sunlight and vitamin D, only our Melanin is made using a different chemical pathway.





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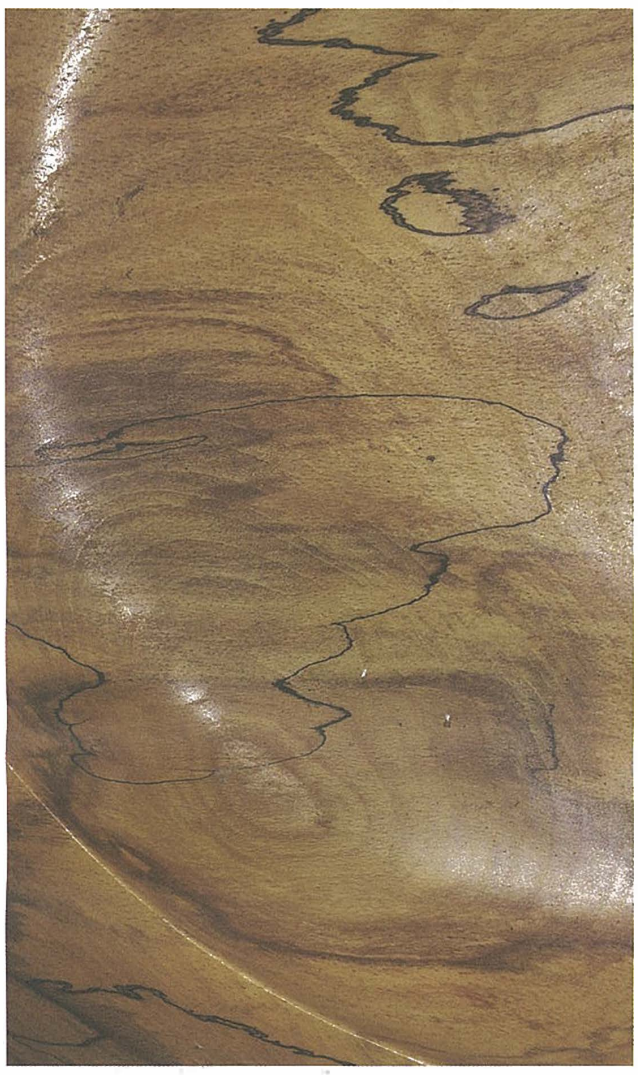

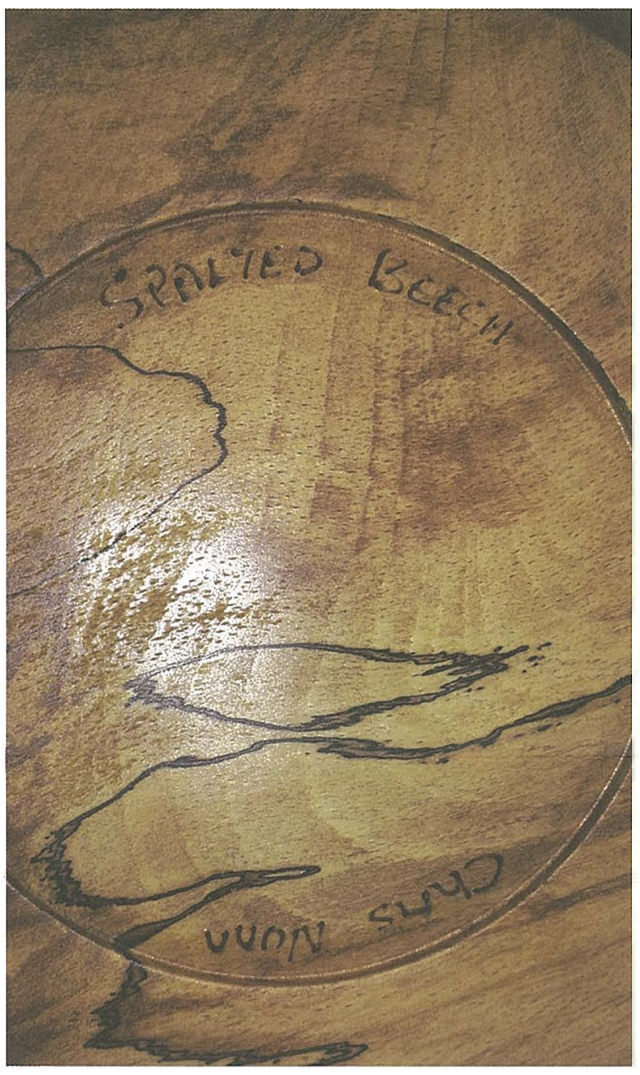

Compared to pigmentation, zone lines remained an untapped science in the art and craft world until the 1960s, when a young Californian called Melvin Benjamin Lindquist revolutionised spalting through his wood turnery hobby. Lindquist and other wood turners at the time took advantage of wood already spalted, but Lindquist also learned how to induce wood piles with fungi giving him a fruitful supply, even though the results were unpredictable. However, under laboratory conditions, Lindquist and his students could not reproduce zone lines. In Europe, we are only now starting to see the development of a niche market for spalted wood products, especially for zone lines.

Today we have a number of scientific approaches, ranging from barely scientific to very scientific; however, we are still unable to standardise the results when inoculating wood that is in keeping with a natural approach. Dr. Sara Robinson of Oregon State University has made huge advances in wood spalting, where she and her team have developed fungal dyes suspended in dichloromethane that can be applied directly to wood with paint brushes, thus dramatically reducing the time frame required to make a saleable product. At Empa, I, together with my colleagues, am aiming to standardise zone line formation for the first time, and to predict how fungi might behave and the likely patterns to follow, from straight lines, to curves, squares and circles. I even envisage to teach fungi how to write, utilising all the fundamental requirements for fungal growth – water, temperature, oxygen and time. Time, in our case, is the enemy. Fungi have evolved over hundreds of millions of years, so we must follow their natural urges with the pace only hastened with small tweaks to the key ingredients.

We chose three pale woods, beech, sycamore and ash, which often inherit a range of defects making them only useful for firewood. The contrast between the black lines and pale wood is particularly appealing, especially when accompanied by bleaching owing to fungal enzymatic activity by some fungi.

I selected 14 strains of the ascomycete *Kretzschmaria deusta* isolated from a single windthrown mature beech tree. *K. deusta* has the ability to produce zone lines in very low wood moisture levels (as low as 8%), as it is able to access static water in secondary cell walls by making small bore holes. Each of the 14 strains (or genotypes) are different, and when paired together, create a range of unique patterns from thick double lines to thin single lines. More strains create a busy or baroque effect, while fewer strains result in a minimalist appearance; both pattern types are highly sought after by enthusiasts of spalted wood. I've also combined *K. duesta* with another fungus that creates the bleaching effect in wood, *Trametes versicolor* and *T. pubescens*. These more aggressive fungi, when paired with *K. duesta,* can inhibit the latter but to great effect, resulting in a range of unique patterns.

Art and science can be harnessed to great effect to produce extraordinary results when fungi and wood are brought together when spalting.