# Design over 400 million years

A journey into the extraordinary micro-anatomy of plants

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# Content

# Foreword

It was the beginning of December 2004 when I first met Fritz at the Wood Anatomy and Tree-Ring Ecology Course in Davos, Switzerland. As a master student, three generations younger, the many stories about his charisma had already reached me so I knew then Fritz was going to be an inspiring mentor. Today, as I write this foreword to his captivating book, I share words that I always hoped I would have the chance to write, but never following his passing.

A few months after meeting Fritz in Davos, I was invited to Birmensdorf (CH) to learn how to prepare specimen slides for wood anatomy on his old Reichert black microtome. That was when Fritz showed me how to truly find the beauty in wood anatomy. He cut my first slide. Slide number 1 of my collection is from a *Rosa chionistrae* twig I collected on Cyprus. I still remember well Fritz's joyful face when he turned to me from looking at it through the microscope. The beauty of the cross-section amazed him: "All roses look the same..." he said, "...aren't they beautiful!". That degree of emotive response typified his attitude towards the study of plant stem anatomy. Fritz had a daily routine based around two distinct activities. He would begin his day in the lab by preparing about 20 slides from plant samples. At home, in the afternoon and evening, he would sit for hours at the microscope describing the anatomical structures and admiring the great beauty hidden in their minute detail. Fritz shared all he found beautiful throughout the microscope with his wife Elisabeth. In many ways, Elisabeth's distance from the study of plant anatomical structure helped Fritz to see a different elegance, one that combined a profound admiration for both the form and function of the structures he was cataloguing.

This book is the result of their passion for the beauty hidden in plant stem cells. The book presents over 100 beautiful anatomical images of plant structures as seen at 1 to 1000 times magnification. A few years ago, Fritz and Elisabeth presented some of these images at the Wood Anatomy and Tree-Ring Ecology Course in which I have been teaching together with Holger Gärtner. At first students were confused. Most students did not have any experience in plant anatomy, and many could not believe the images they were seeing were images of plant cells. They saw angels, stars, waterfalls, insects, snowmen… Elisabeth was there to inspire their imagination, and Fritz was there to provide the nomenclature, anatomical descriptions, and physiological details. As you will see both Fritz's and Elisabeth's approaches are pervasive throughout this book. Though every image is accompanied by a short caption that provides some context about what one is seeing, the space left for your imagination is immense. Beware: you can get lost in this book. Regardless of whether you are going to use the book to relax your mind after a busy day, refresh your plant anatomy knowledge, or seek inspiration for your next graphic design project. As long as these images inspire you, Fritz and Elisabeth have accomplished their goal. This book is the collection of their favorite images.

Please enjoy!

Alan Crivellaro
Cambridge, April 2020

# Design over 400 million years

The study of the characteristics and distribution of microscopic features in wood and bark started at the end of the XVII century (Hooke, 1665) and is still going on (Crivellaro and Schweingruber 2015, Schweingruber and Börner, 2018). Wood anatomists have focused their efforts on the stems of dicotyledonous trees found across the world. Until now, the majority of wood-related research has focussed on wood identification and the physical and chemical properties of wood, together with specific economic problems. Microphotographs of wood structures presented in the literature convey information clearly and also appeal to our scientific interest. More often than not, microscopic structures also combine scientific interests with an aesthetic appreciation of the natural beauty. Our inspiration for this book originates from the work of Ernst Haeckel (1834 - 1919), whose detailed botanical illustrations capture the beauty of patterns in nature. We may not be able to replicate Haeckel's drawings but we use modern sample preparation for anatomical analyses and photographic techniques to highlight internal plant structures in previously unseen detail and beauty. Seen under the microscope, these plant structures may seem at first sight rather unattractive due to their lack of colour. However, when stained with pigments and illuminated with light through a microscope, plant cells are seen in varied unusual ways.

By staining anatomical thin wood sections with different colours, and by using microscopes equipped with a normal and polarized light source, we transform pale and seemingly simple structures into colourful works of expressive art. First, due to the different chemical composition of plant cell walls, we are able to use'Safranin' and 'Astra blue' pigments to highlight lignified structures in red and less lignified cell walls in blue, respectively (Gärtner and Schweingruber 2013). Second, with the microscope we obtain two major effects; akin to daylight and night. Under normal light the backdrop of the microphotographs is illuminated with clear, bright light. Polarized light yields a darker background effect, but tells us more about the plant structure. Polarized light is reflected differently depending on the orientation of the cell-wall microfibrils: cell walls are brighter if the cellulose is regularly arranged and darker if they have an irregular structure.

Through combining physical and chemical information on plant structures in an expressive and accessible format, we hope to further inspire human curiosity. The artistry of nature, as we see it, is an accidental bi-product of genetic adaptation with the aim of designing a perfectly functional unit. The process probably began with the development of the RNA approximately 2500 million years ago. Only when the Earth's atmosphere contained the right balance of gases for the sustenance of terrestrial organisms could the next evolutionary phase begin. Geologists suggest that the step of plants from water surface to land started 400 million years ago - a timespan 200 times longer than a human time presence on land.

The goal of this book is to combine nature's attempts to build working designs with the human ability to relate form and expression with aesthetic feelings. We compare function within many beautiful structures, e.g. by comparing million years old fossil

stems with those of currently living plants. We embark upon an exploration of plant evolution, and wander between anatomical adaptations occurred over millions of years as we flip through the pages of this book.

Our catalogue of images shows the hidden attraction of nature and we hope to inspire designers, who, we believe, could implement plant structures in textile, wallpaper and carpet designs and other artistic outlets.

Fritz H. and Elisabeth Schweingruber
Birmensdorf, December 2019

## References


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Gärtner H., Schweingruber F. H. 2013. Microscopic preparation for plant stem analysis. Kessel Verlag.

Hooke, R. 1665. Micrographia; or some physiological descriptions of minute bodies made by magnifying glasses with observations and inquiries thereupon. London.

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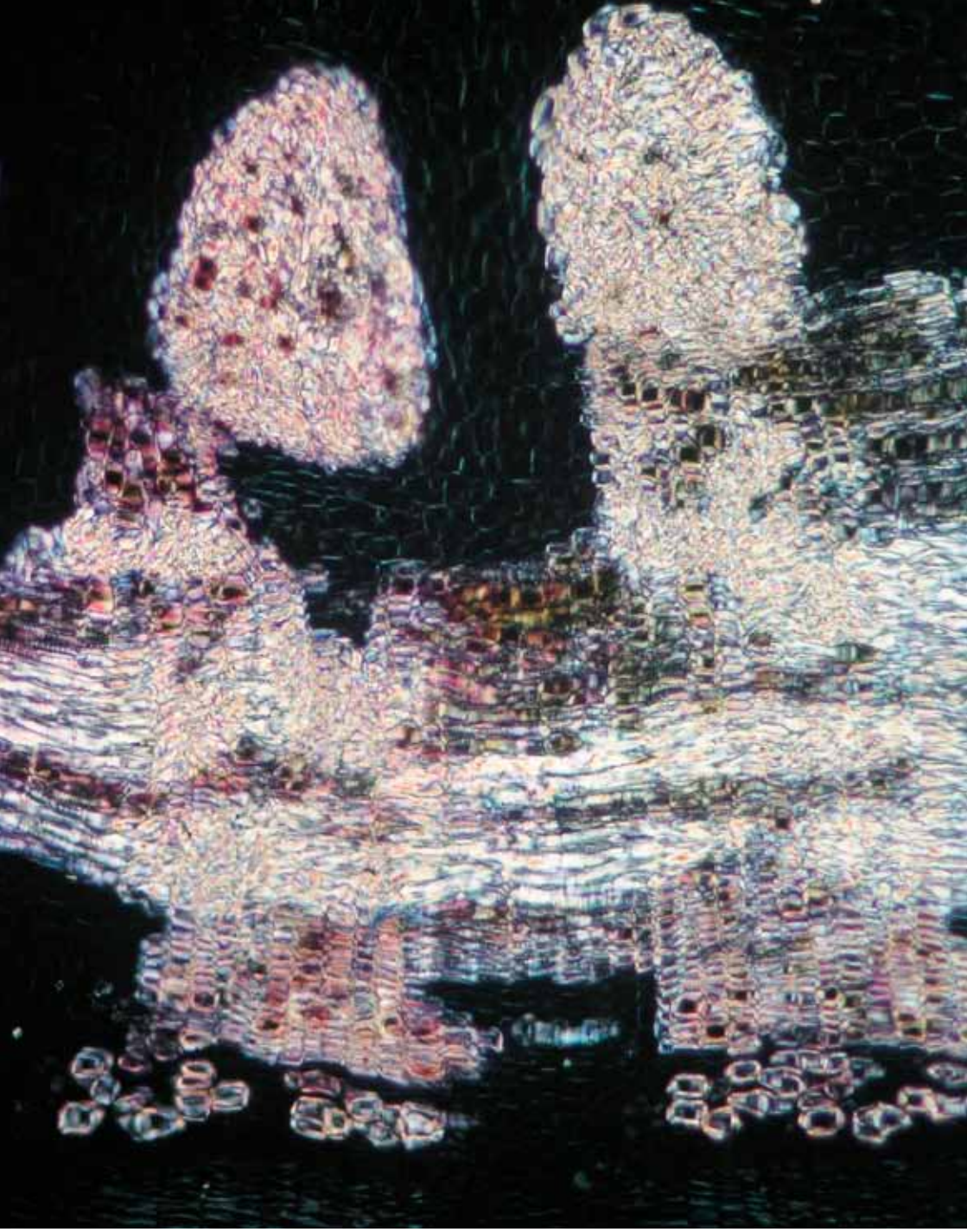
# Art

Plant evolution creativity has been producing structures appreciated for their beauty and emotional power.

Angel like functional leaf structure with long wings in a bud. *Corylus avellana* L. Polarized light. Magnification 400x.

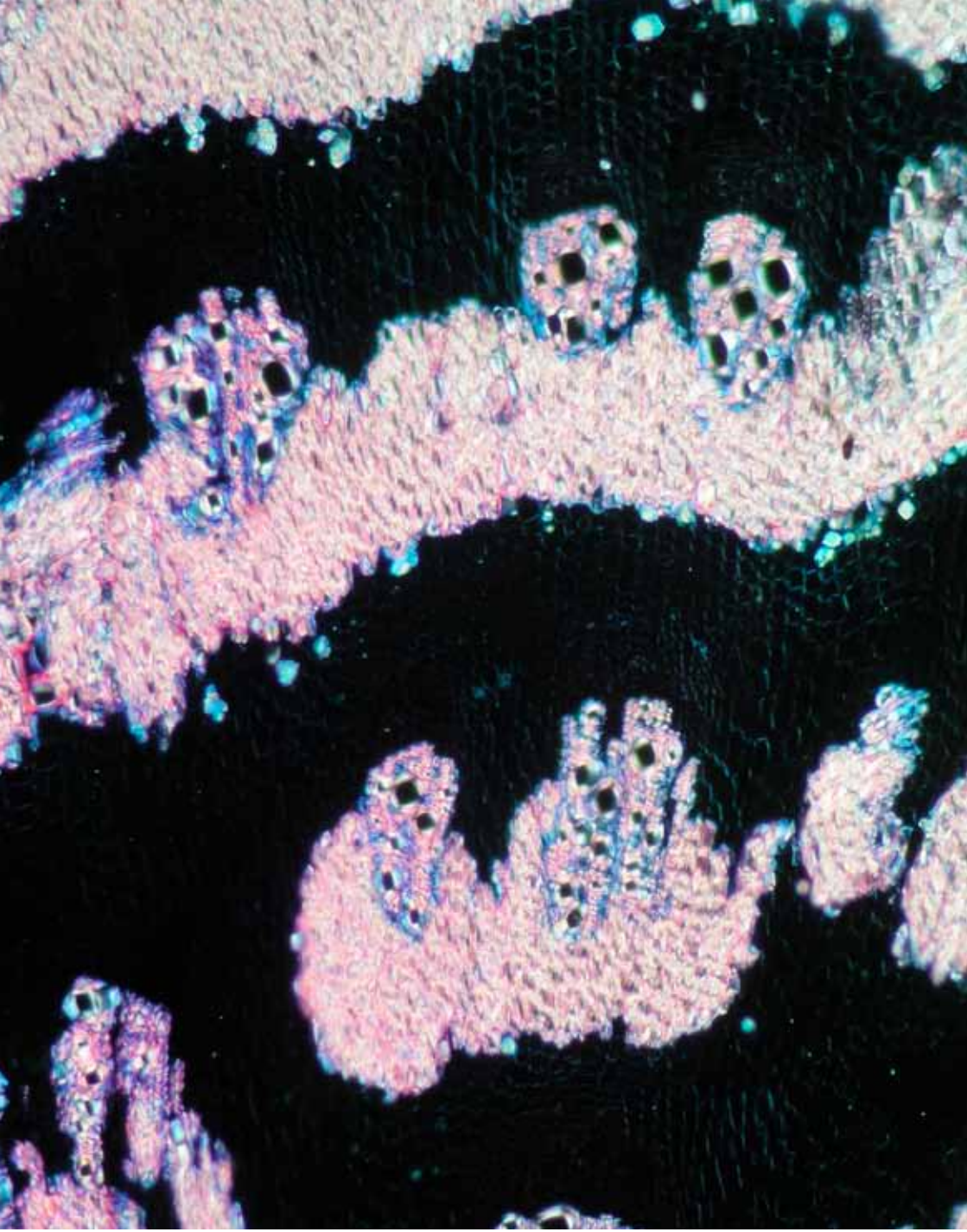


Bright cell walls in wood and bark. *Serratula tinctoria* L. Polarized light.
Magnification 200x.

Stem structure of a fern. *Pteridium aquilinum* L. Polarized light. Magnification 40x.

Ray of a beech through the phloem. *Fagus sylvatica* L. Polarized light. Magnification 400x.

Wavy shades from crystal sand in the bark. *Taxus baccata* L. Polarized light. Magnification 1000x.

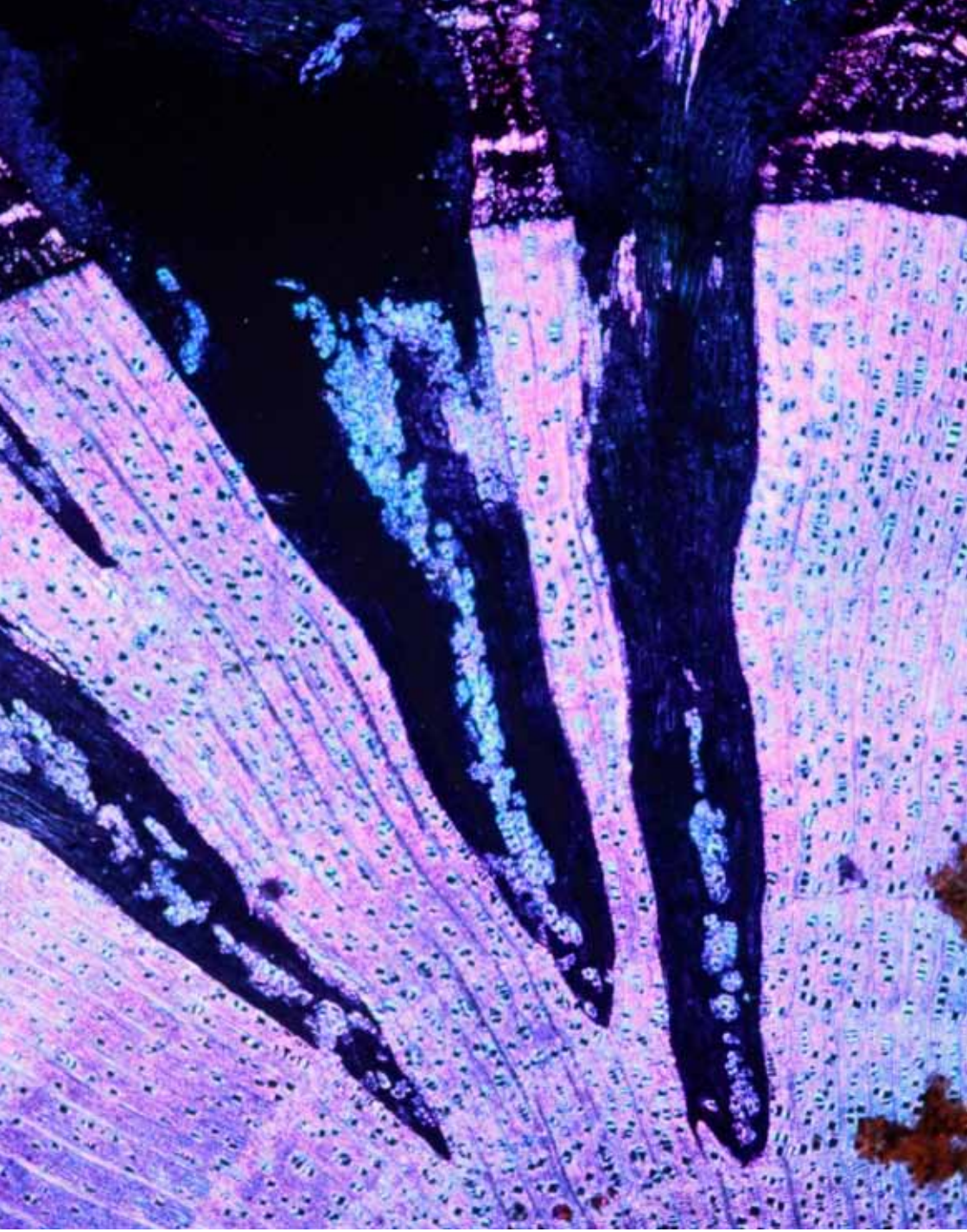


Wood. Unidentified species. Polarized light. Magnification 200x.

Bark. Unidentified species. Polarized light. Magnification 400x.

# Firework

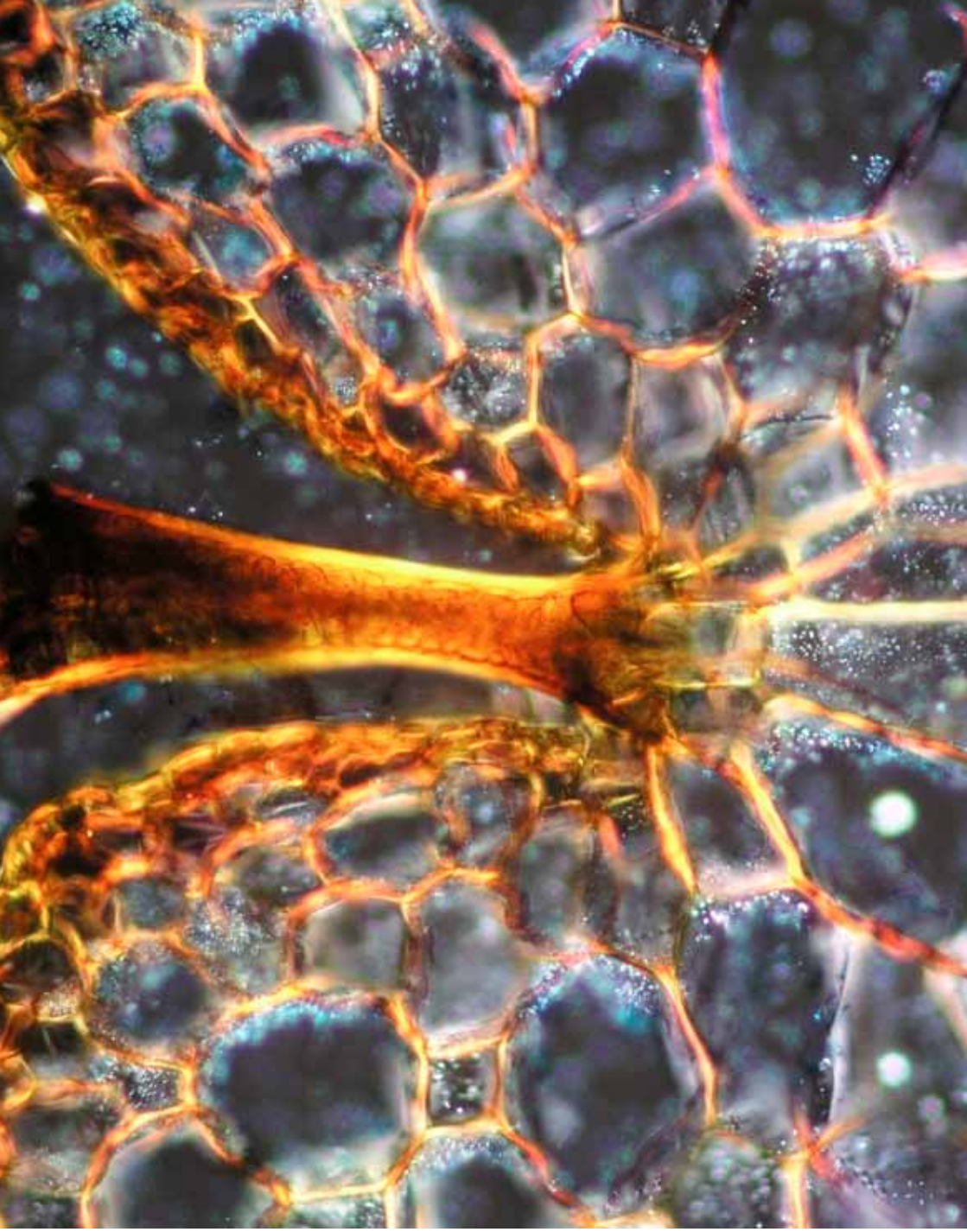
Sspectacular effects of light explosions obtained when cell walls and crystals are ignited by light throughout the microscope.



Misteltoe haustorium in a apple tree branch. *Viscum album* L. and *Pyrus malus* L. Polarized light. Magnification 20x.

Elongated crystals. *Vitis vinifera* L. Polarized light. Magnification 400x.

Radially arranged vessels in the wood. *Crepis tectorum* L. Polarized light. Magnification 200x.



*Davallia canariensis* (L.) Sm. Fern. Rhizome. Polarized light. Magnification 400x.