

LIGNUM LUX



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BY
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CREATIVE INQUIREY INTO WOOD, LIGHT AND THE MICROSCOPIC
MANIPULATION OF WOOD

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INTRODUCTION

Science and design combined is a necessary combination; without one, the other is futile. Designing is a process which is happening not just in the studio but everywhere for the modern designer. We now have instant access to pocket-sized computers, these can take down notes, photographs, videos and sounds followed by a simple tap on the screen to transfer them directly to a client or to online storage; this technology alone expands our design capabilities, making us become more able than ever to research, produce and present.

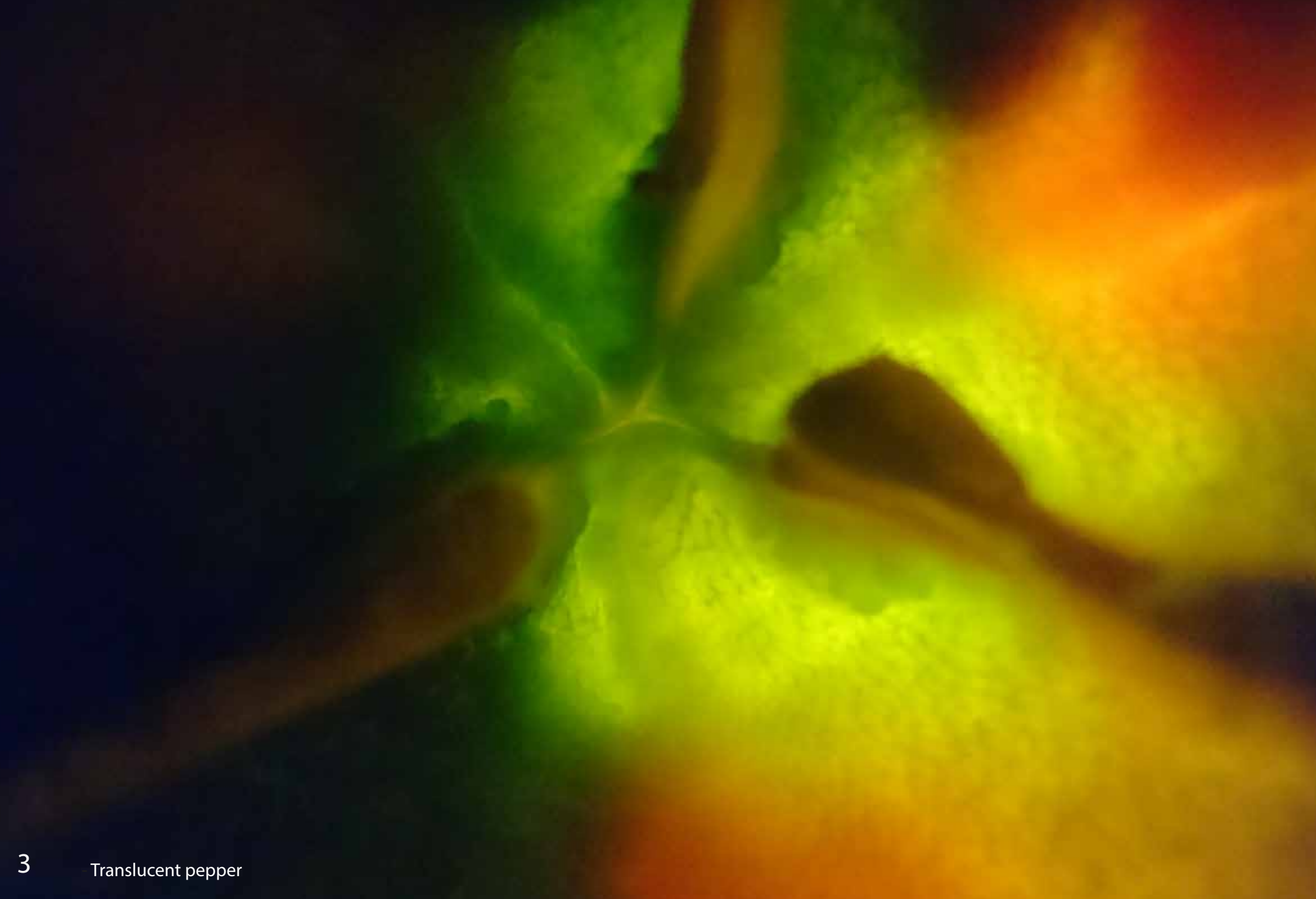
In Latin, Lignum Lux translates roughly to Wood Light. The name perfectly describes the project which all started from a passion for nature and a strong interest in the properties of natural plant materials.

During the early summer of 2018 I started researching innovation in wood science and technology with the idea to find new directions, exploring and manipulating the natural material. In order to achieve this, I must understand and manipulate the ultrastructure of wood. Wood samples have been manipulated through a series of experimental processes with various new outcomes, each giving the wood new properties to design from. Elegant warping and translucency of wood can be made possible by the manipulation of the ultrastructure and can create a warm natural light which creates a feeling of calm, like that of a controlled flame.

Some information from the processes are left out of this document due to intellectual property protection, such information can be found in the project research sketchbooks and technical note books.



Translucent leaf



THE BEGINNING

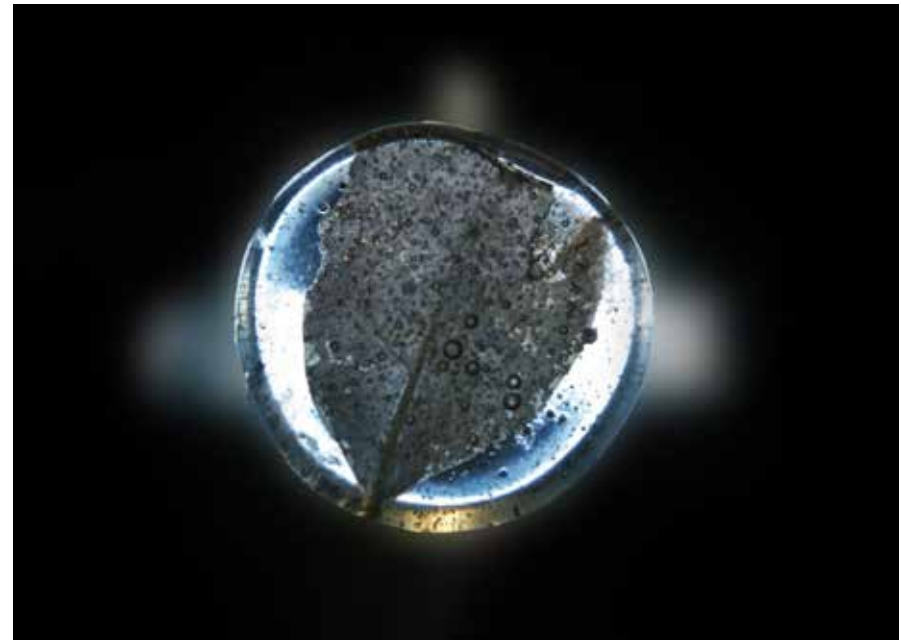
I have a history in engineering, product design and a long job in my teenage years as an assistant tree surgeon. It's become clear to see the inevitability of my past having informed my research direction today.

The urge to take things apart, build things and experiment throughout my life has led me to an interesting project where I was experimenting with making skeleton leaves also known as transparent leaves. During this experiment I decided to place a small piece of wood in the detergent solution which contained the leaves, this was to see if the solution would have a breakdown effect on the wood sample.

While this experiment was successful it has encouraged me to broaden my experimentation and to discover new ways of manipulating the natural material.



- Cutting the burl from a felled Beech tree



- A skeleton leaf housed in resin.



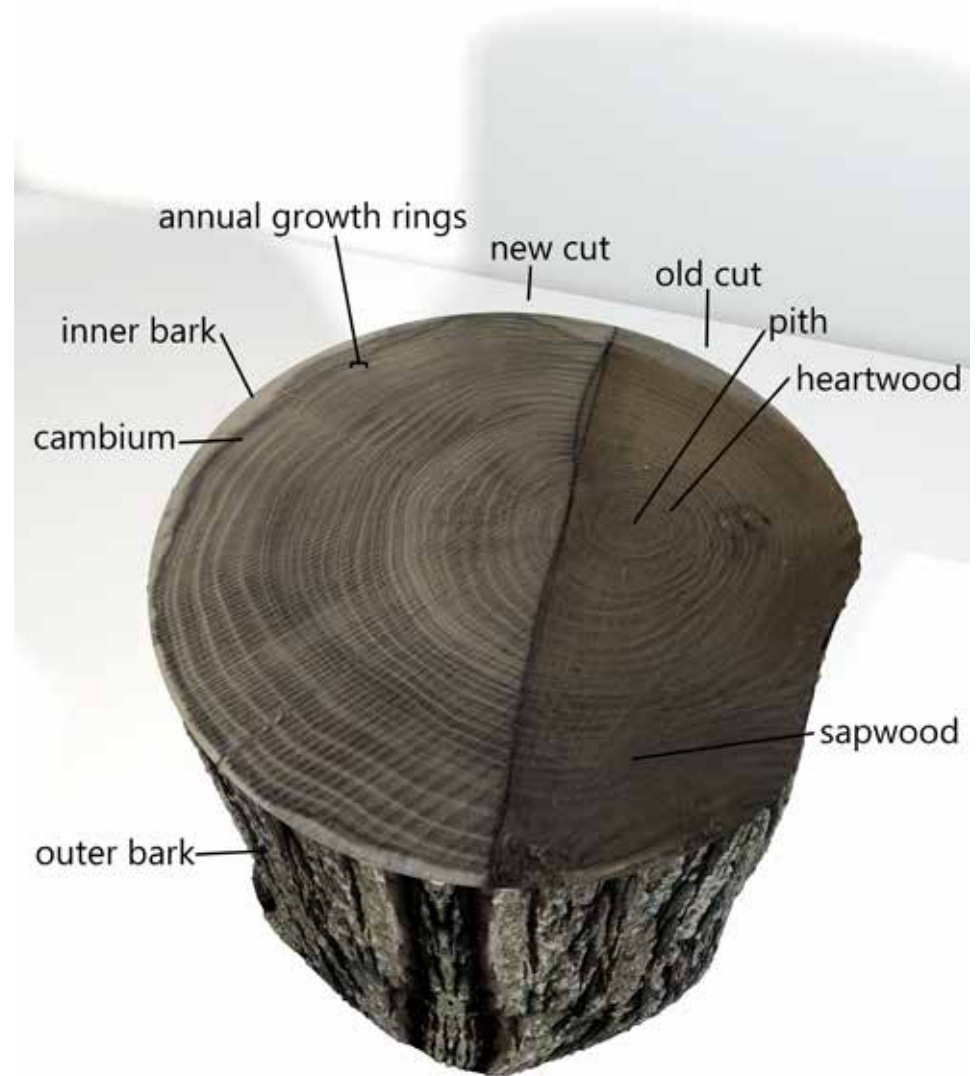
WOOD

There are over 62,000 tree species around the world, wood is one of the most abundant and diverse biomaterials available to the planet today. There is an urgent need for a more sustainable future, developments in wood research help to phase out unnecessary building materials and therefore replacing less sustainable materials with wood. Wood has a very complex internal arrangement which makes it more difficult to manipulate and control.

During the early summer of 2018 I started researching innovation in wood science and technology with the idea to find new directions, exploring and manipulating the natural material. During this process I discovered the research of Yuanyuan Li, Qiliang Fu, Xuan Yang, Lars Berglund (Author) and their research paper Transparent wood for functional and structural applications (2017). The research paper was a beneficial starting point, and In order to achieve my goal, I must first understand the ultrastructure of wood to then manipulate it.

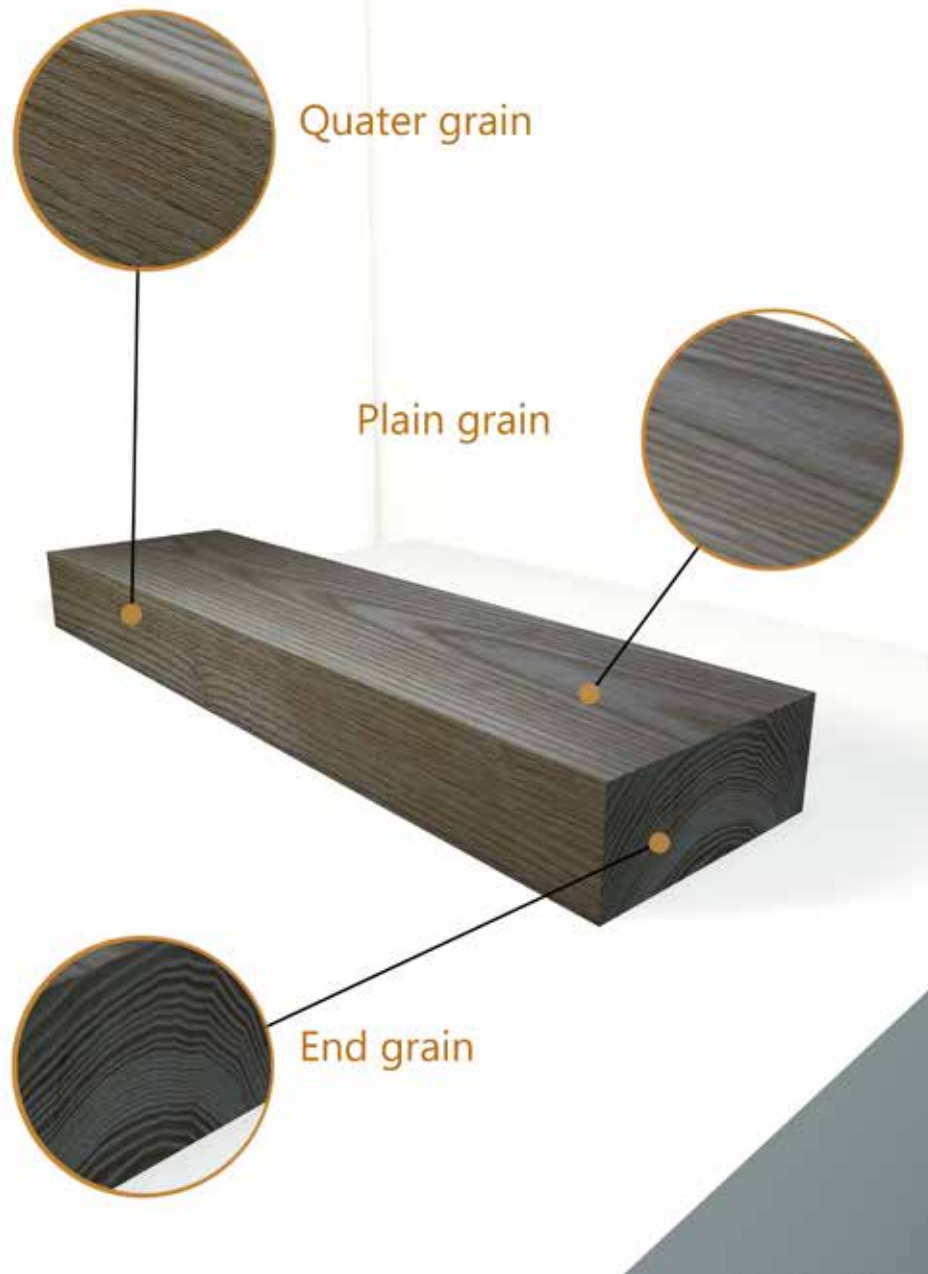
From the outside working inwards: The outer and inner bark protect the tree from the elements, insects, animals and fungi. The cambium produces phloem on the outer side, making up the inner bark, and xylem on the inner side for new sapwood growth. The annual growth rings consist of the older dried up dead cells and the more porous newer wood. The heartwood consists entirely of dead wood cells which are the bulk of the trunk's strength. Some younger tree's have a pith which is in the very centre of the heartwood and contains nutrients for the tree, and often gets replaced as the tree ages.

A freshly cut piece of end grain makes it easier to distinguish different wood species and to understand the age or growth of the tree. The annual rings show the tree's lifetime, telling a story; more and less favourable growing conditions will be scribed in the tree's grain formation throughout each season. For example, the south west side of the tree in the diagram shows more growth, therefore it received more sun for photosynthesis. The more uniform gaps between the rings show where seasons have been wetter (wider) or drier (narrower), keeping a detailed record throughout the tree's life, which is known as paleoclimatology.



- Labeled example of a tree stump (CAD render, no species in particular).

Flat Sawn Ash Wood (*Fraxinus excelsior*)



Wood has many variations of grain and structures which can all shrink and therefore allow the wood to warp over time. Some woods can be more efficient for use as building materials, whilst others are used for their sound enhancing ability. Wood can also be used as a decorative material celebrating the woods natural beauty. It is necessary to understand the grain formation on your wood choice if a project has a specific outcome or may involve moisture or various stress's and strains.

- Flat sawn piece of ashwood and it's various grains.

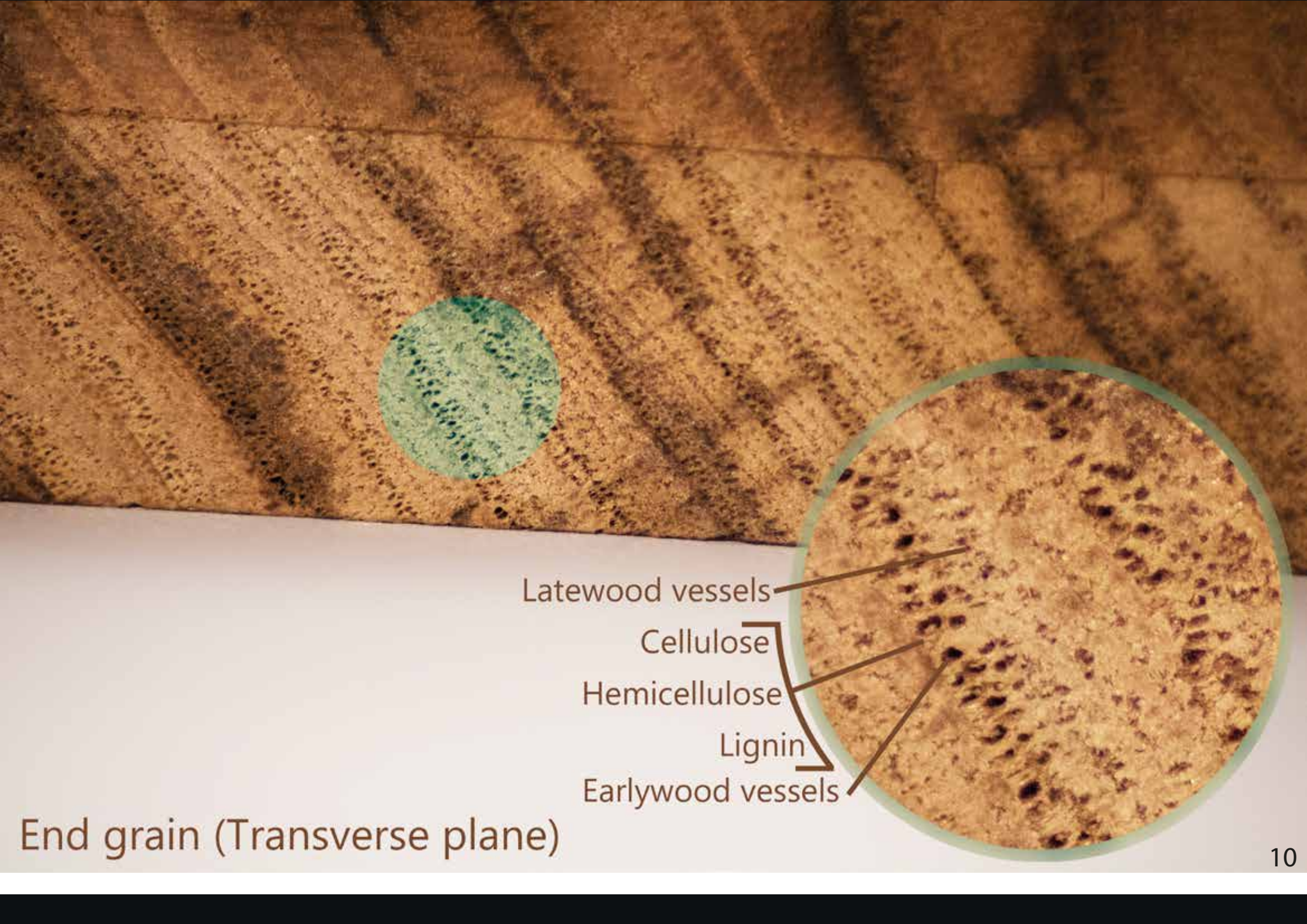
CLOSE UP WOOD ANATOMY



By wood anatomy, I am referring to the inside of the living tree, we'll be looking at manipulating the Ultrastructure in order to alter the properties of the wood.

Latewood vessels (the small openings) form during the end of the growing season (late summer) adding strength to the tree. Whilst earlywood vessels (the large openings) grow at the beginning of growing season (late spring), the larger openings seen in earlywood are better for the transportation of nutrients throughout the tree.

Latewood vessels and earlywood vessels both consist of xylem. The wood fibres surrounding the vessels are made of cellulose, hemicellulose and lignin. Lignin is effectively the concrete keeping the woodstructure, Xylem vessels intact.



Latewood vessels

Cellulose

Hemicellulose

Lignin

Earlywood vessels

End grain (Transverse plane)

Wood is anisotropic and therefore it has different properties across different directions. When wood dries too quickly it splits or checks. The images on the left show what happens when wood is dried too quickly. I used a heat gun to carefully heat the wood sample. During the process I used a macro camera lens for close up images of the wood to show the sample transforming over time.

The wood splits radiating from the centre of the end grain. When drying wood you want most of the moisture to leave through the bark to help to prevent splitting.



- Wood force dried for analysis (end and quarter grain)



CHEMICAL EFFECTS ON WOOD

Various chemicals can effect woods microstructure. Some chemical derivatives of sodium can have a delignification effect on wood, which is one step in making the wood more translucent.



- Untreated wood samples



- Wood treated with sodium derivatives



- Wood treated with hydrogen peroxide

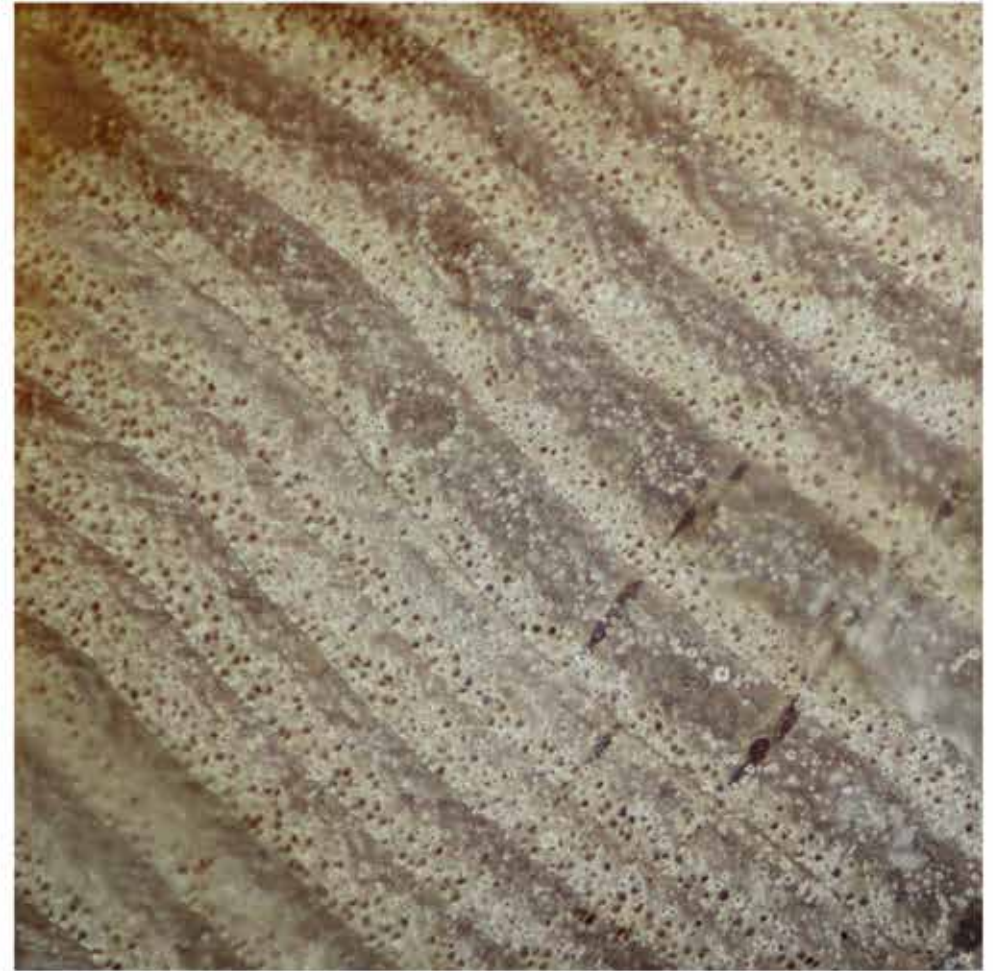
Hydrogen Peroxide helps create translucent wood by preserving the remaining lignin within the wood and modifying the remaining structures colour making it brighter, therefore allowing better light transmission through the wood (far right photo, page 13).

Lignin is the foundation of the woods structure, it also gives wood it's brown colour. This is demonstrated by the darkening colour of the wood samples and by the surrounding solution becoming a darker brown colour (middle photo, page 13).

The untreated wood samples show their natural colours and opacity. When comparing them with the samples treated with sodium derivatives the darkening still comes with mild tranlucency, but the bulk of the translucency comes from the hydrogen peroxide stage.

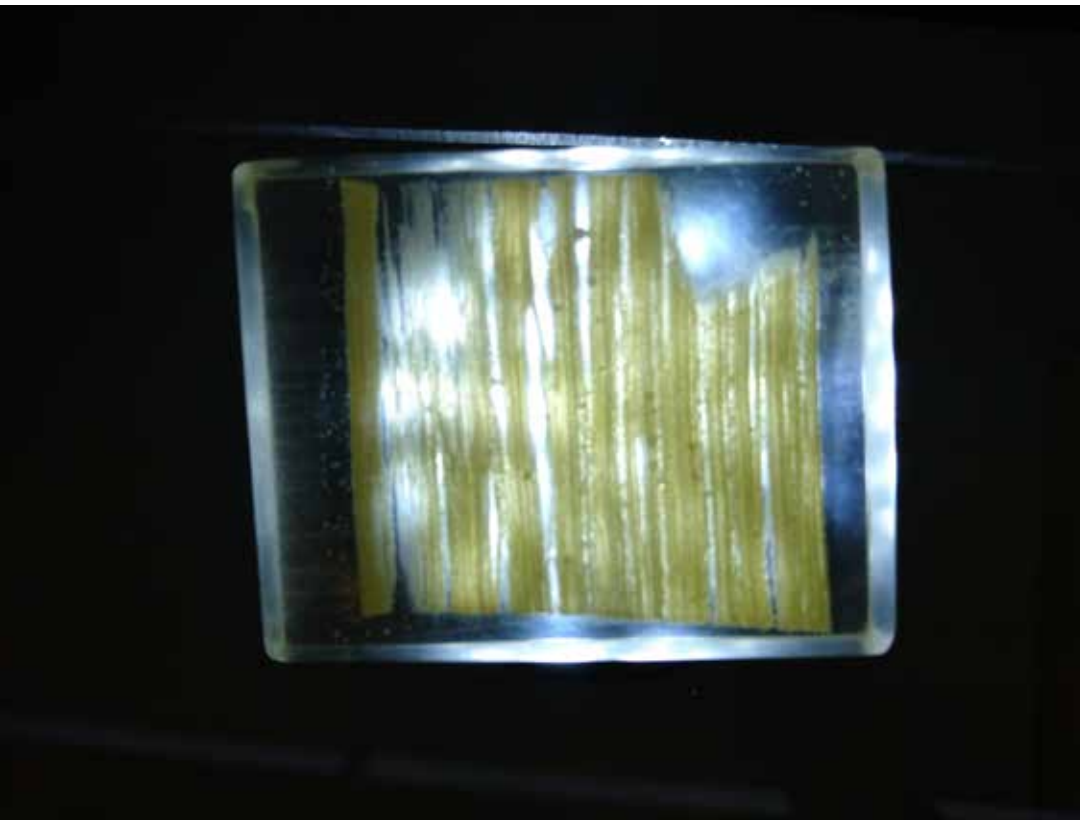


Wood before treatment



Wood after treatment + epoxy resin

Drying the wood whilst maintaining it's new properties and structure is a difficult stage in the process. In the photograph on the right I used acetone to infiltrate the moist wood along with epoxy resin with an acetone based hardener to evaporate the remaining moisture and strengthen the wood. Some chemicals from previous treatments were still present; shown by the white misting seen in the image to the right.

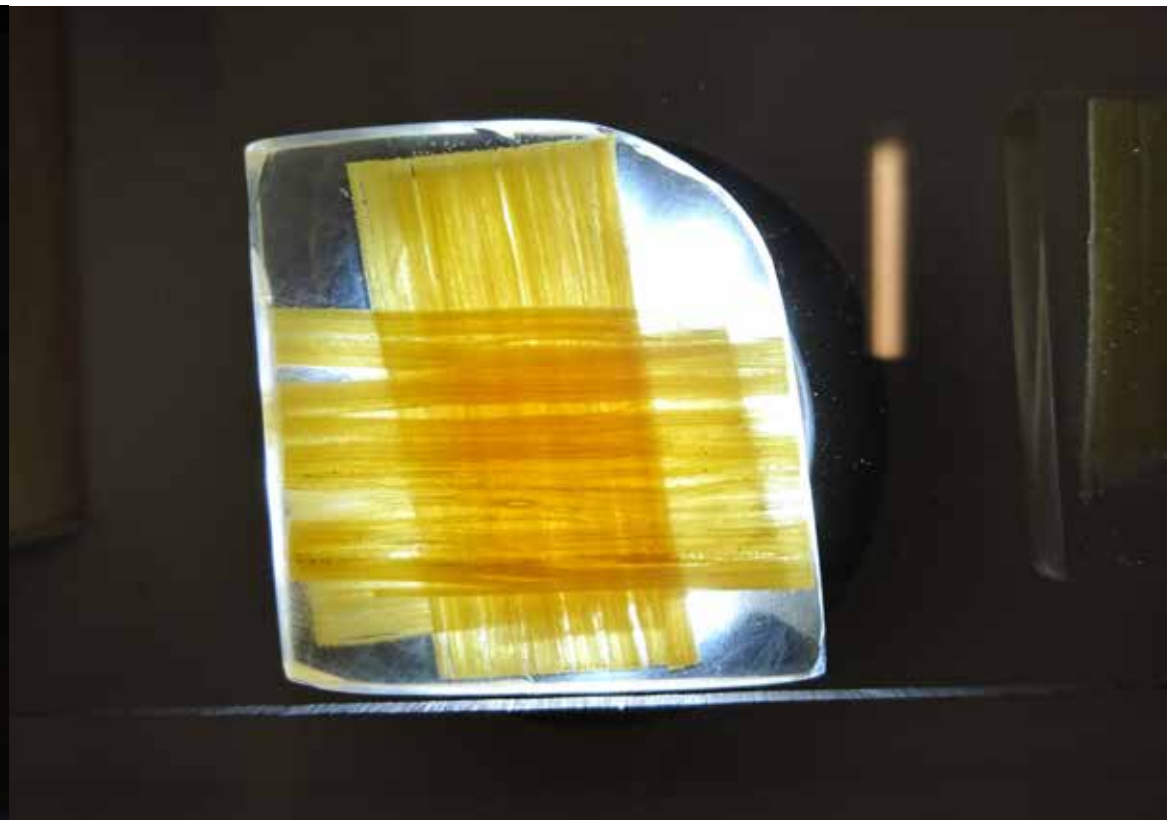


Illuminated wood veneer in resin

The treated veneer samples had become drastically more translucent, although they had also begun to tear because I allowed them to dry naturally.

The samples above were treated in the same way to the samples on page 15, but to ensure additional chemicals didn't react with the epoxy resin I soaked the veneers in alcohol prior to adding the resin, giving a clearer finish to the resin wood samples.

The wood sample on the right above shows long grain veneers stacked so their grain is going in a perpendicular direction to its neighbouring layers. This stacking technique created tonal patterns from the decreasing amounts of light reaching the following layers outwards from the light source.



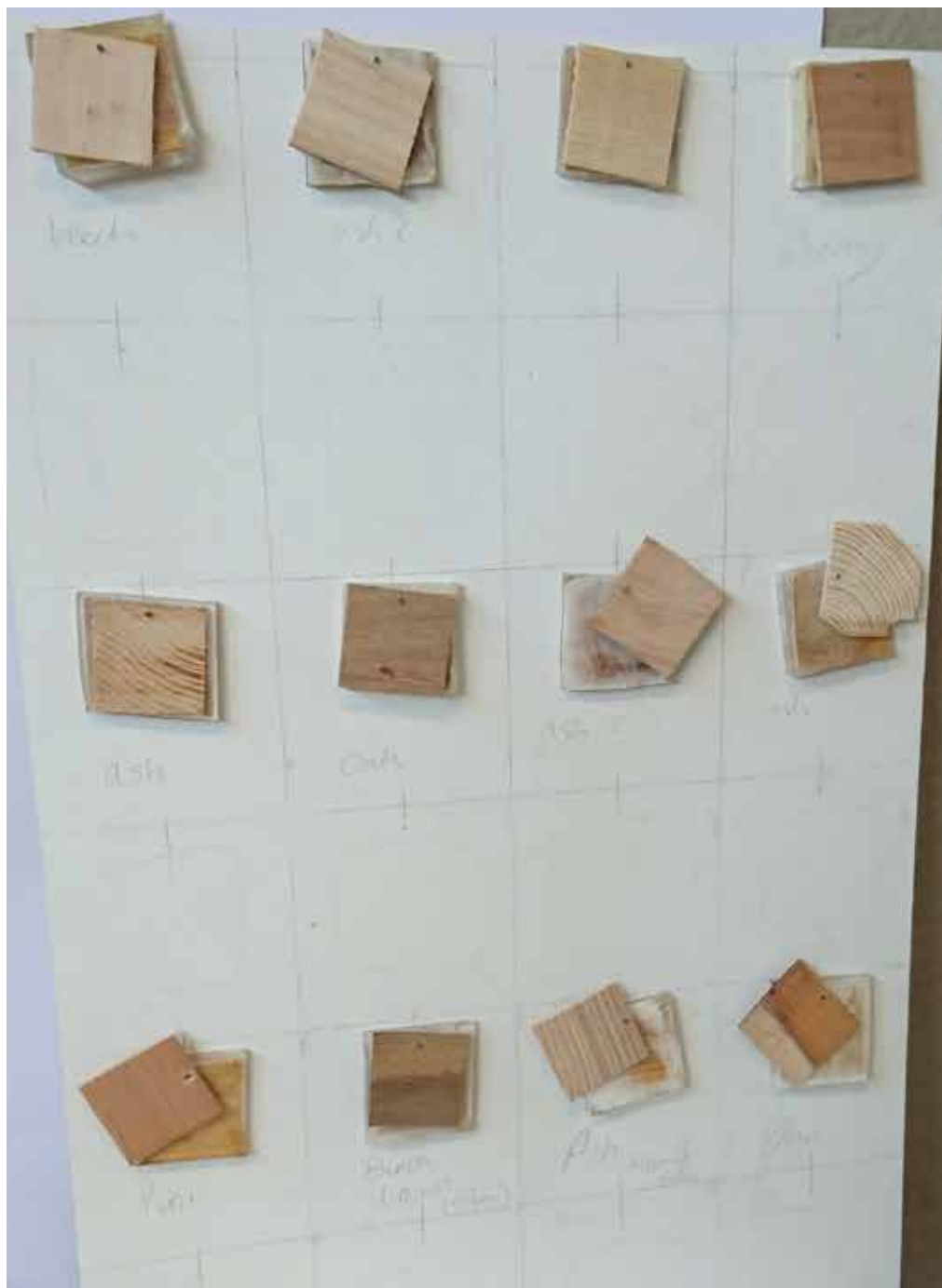
Illuminated layered wood veneers with crossing grain in resin



wood samples after treatment

The series of images to the left are various wood samples which were delignified and bleached. The samples are: Beech, Ash, Cherry, Oak, Pine, Robinia and Yew. The white mist is unwanted chemicals which I failed to remove during the cleaning process. They highlight and outline the vessels and wood structures which was interesting to examine and highly beneficial to understanding what woods to use for the processes ahead.

The photo on the right shows the same series but displayed with their untreated matching partner. Unfortunately the unwanted chemicals that were still present effected the curing of the resin and the white mist worsened accross some of the samples.



wood sample board, before and after treatment

The Ash samples were the most translucent and the Robinia had a much darker finish compared to the other wood samples. The end grain of the wood also provides better light transmission due to the vertical direction of the woods fibres and vessels.

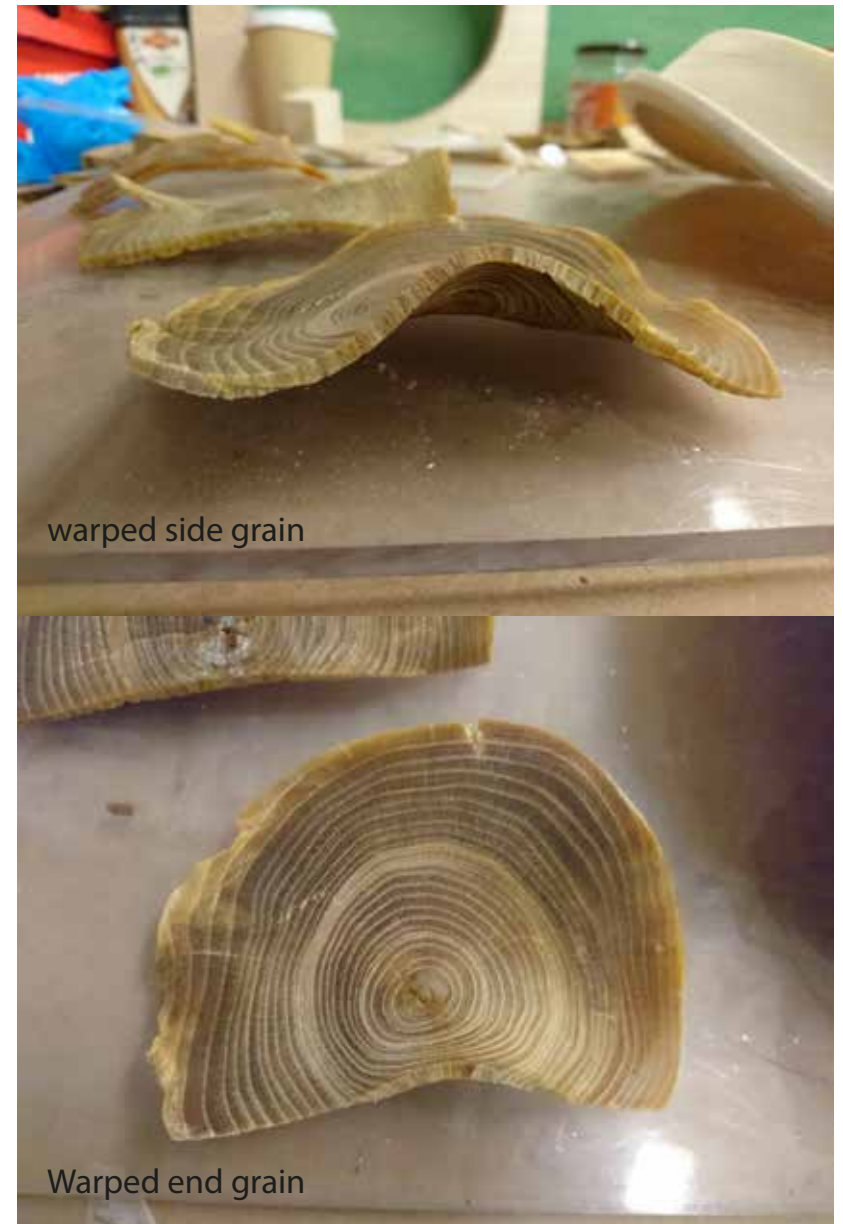


Ash wood translucent end grain

ROBINIA TESTS



When the epoxy resin cures it shrinks which leads to the worsening of checking and cracks on treated wood samples. The acetone based sealer provided a quicker drying time and allowed the wood to maintain a more natural look with less cracking.



- *Robinia pseudoacacia* (Black Locust): The samples had their latewood lines partially carved out to allow for more translucency and movement when shrinking.

WOOD WARPING



Diagram showing the movement of Ash wood (end grain)

Wood warping is referring to the shrinkage and 3D movement of the wood during the drying process.

The diagram to the left is a render of the End grain of ash wood, showing what will happen to the wood after treatment. Treated wood has a more exagerrated motion than that of normal wood, this is because of the removal of the lignin.

Warping mainly happens during the drying process of the wood, the tension is releived across the plain grain as the growth rings begin to reverse their curve (seen in the diagram on the left). The plain grain also affects the final form by the formation and distance between the grain and it's distance away from the heart wood. The heartwood is much denser and therefore allows less movement when the wood warps. This makes choosing the right grain structure importent during the Lignum Lux making processes.



CHERRY BURL



NaOH + Na₂SO₃
Only

NaOH + Na₂SO₃
followed by
H₂O₂

Cherry Burl solution separation diagram

The cherry burl was placed in the solutions shown above, the top section of the wood became more coloured by the lignin extraction. The bottom section became more translucent and lost the majority of the colour extracted from the first solution.

The vessel has a very sinister or antique look compared to the vessel before treatment. I feel as if the character of the wood has been released to provide us with more detail and colour across the upper portion.



Touich attachment, turning Cherry Burl



UNIFORM ROBINIA

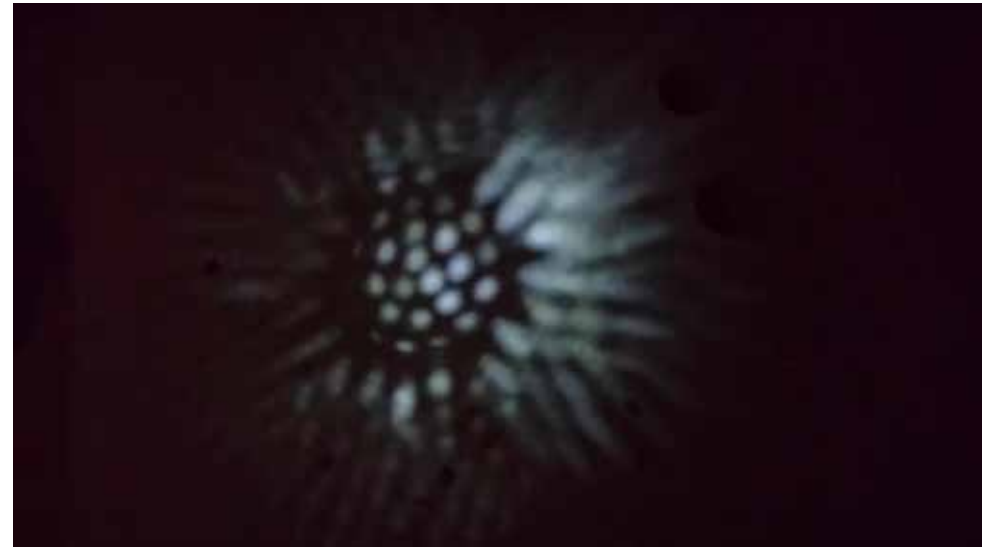
The Robinia was treated from the inside of the vessel using the two solutions used on the cherry burl. The wood moved and shrank into an interesting shamrock-like shape. The base maintained a circular shape, whilst the warping shows correlation with the grains formation which gives the final vessel it's very organic form.



HONEY POT

The honey pot is made from robinia using the same process as the Uniform Robinia, but rather than drying using acetone based sealer solution, I used acetone and an acetone based epoxy resin to allow the acetone to replace the moisture and evaporate upon the duration of the resin curing.

The warping created a taper to the top of the vessel and minimal warping around the lower half. This piece is much smoother and cleaner finish, and is called the honey pot because of it's final form and tones.



Hypnotic light illusion produced by the base of the Honey Pot



Honey Pot



Honey Pot before treatment

Light can be processed and seen in many different ways. Humans are only capable of processing a small quantity of the infinite light spectrum. Bugs and animals can see their own perception of light and the world around us with varying focal lengths, colours ranges and multiple eyes with different functions. This project is about what I see - light

RESEARCH TRIP



When light interacts with our eyes, it depends on the object's distance away from our eyes to how much detail our eyes can perceive. The further away an object, the less information our brains can decode and the closer an object is, the more information our brains can receive.



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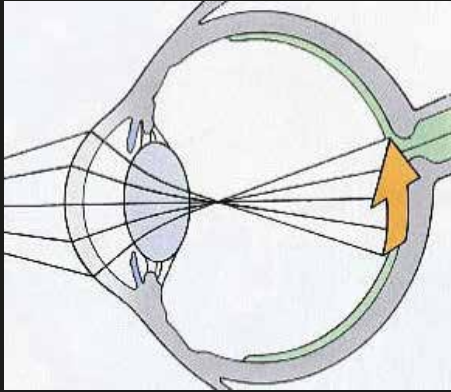


310X240

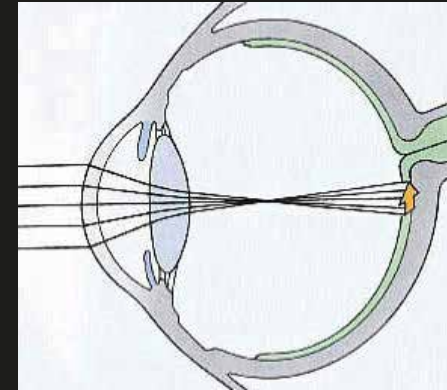
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A Photographs resolution (in pixels) is a perfect example of how much detail changes by the distance. As you move further away less information in the form of light hits the sensor, thus things become 'pixelated'. On the right although the image with less information is blown up, it still has less data than the image of the same size above. Therefore 6000x4000 images are an example of what can be seen at a closer range, whilst the 310x210 represents the data which is processed from a longer distance away from the object.



Vision Aware eye diagram. website: <http://www.visionaware.org>
Elongated lens focusing on far away objects.



Vision Aware eye diagram. website: <http://www.visionaware.org>
Rounded lens focusing on near objects.



The lens of the eye, which is behind the iris and the pupil, bends to direct light allowing us to focus to objects at various distances. The camera works similarly by moving the lens closer or further away from the sensor to adjust the focus.



variations of previous images



The light can be bent and missaligned by a suprising amount using a digital camera, this can paint beautiful images of nature unlike what we can see with our own eyes.



variations of previous images

Translucent



Leaves are translucent meaning light can pass through them, this is so the leaves can absorb as much light as they can for photosynthesis. Without photosynthesis the tree would starve.





The light produced and manipulated by nature can be found in so many beautiful places once you intentionally look for it. The silhouette of the trees highlighted by the sun and the Leaves as the glow green or brown tones by season as the sun transmits light through the fibres which traps other colours like a natural light filter.





The close up and far away photographs show variation in the way the light is captured.

The close up shot doesn't allow as much light to reach the sensor and a small tint of colour remains. The far away photograph is overexposed and allows more colour and a lens flare created by the scattering of bright light.

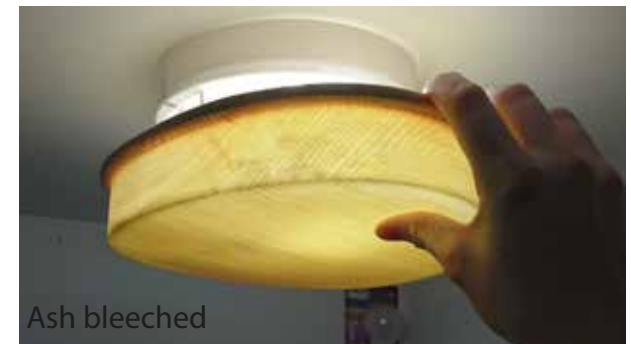


SADDLE LIGHT



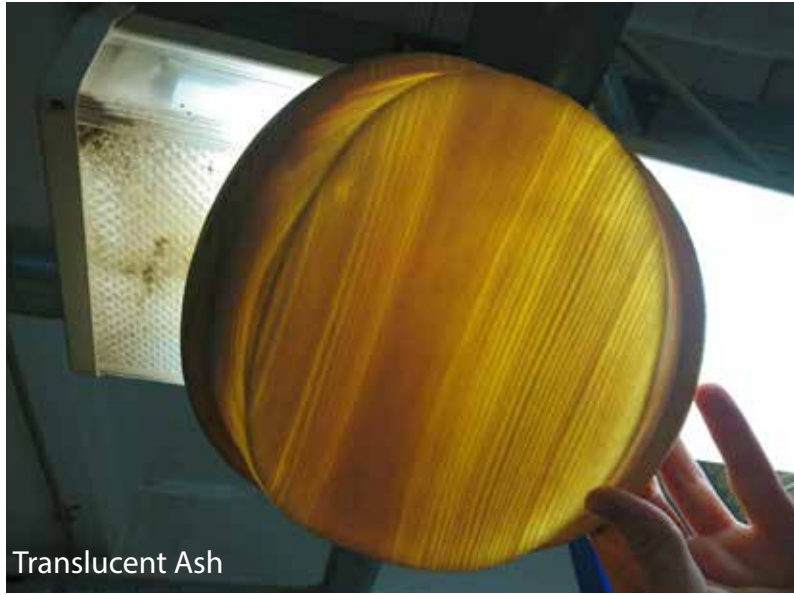
The Saddle Light was the first of the four lights. The wood was carefully selected for its specific grain formation. The lamp displays elegant curves formed during the drying process of the light. The ambience is a product of the wood itself which gives the light the ability to transform a low lit room into a relaxing, ambient environment.

The images on the right show the production stages of the Saddle Light through delignification to the final product.

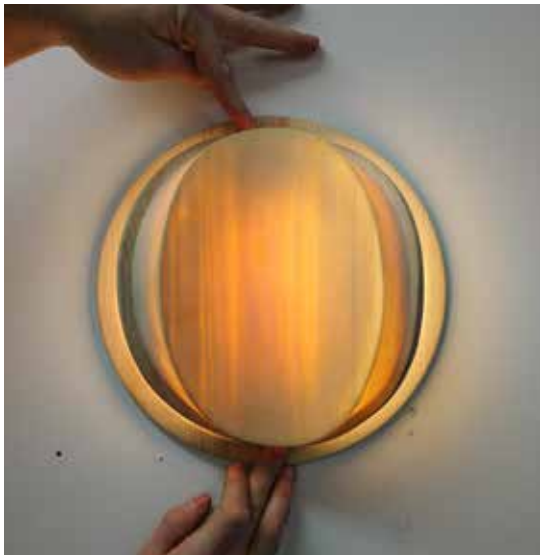




Ash warped



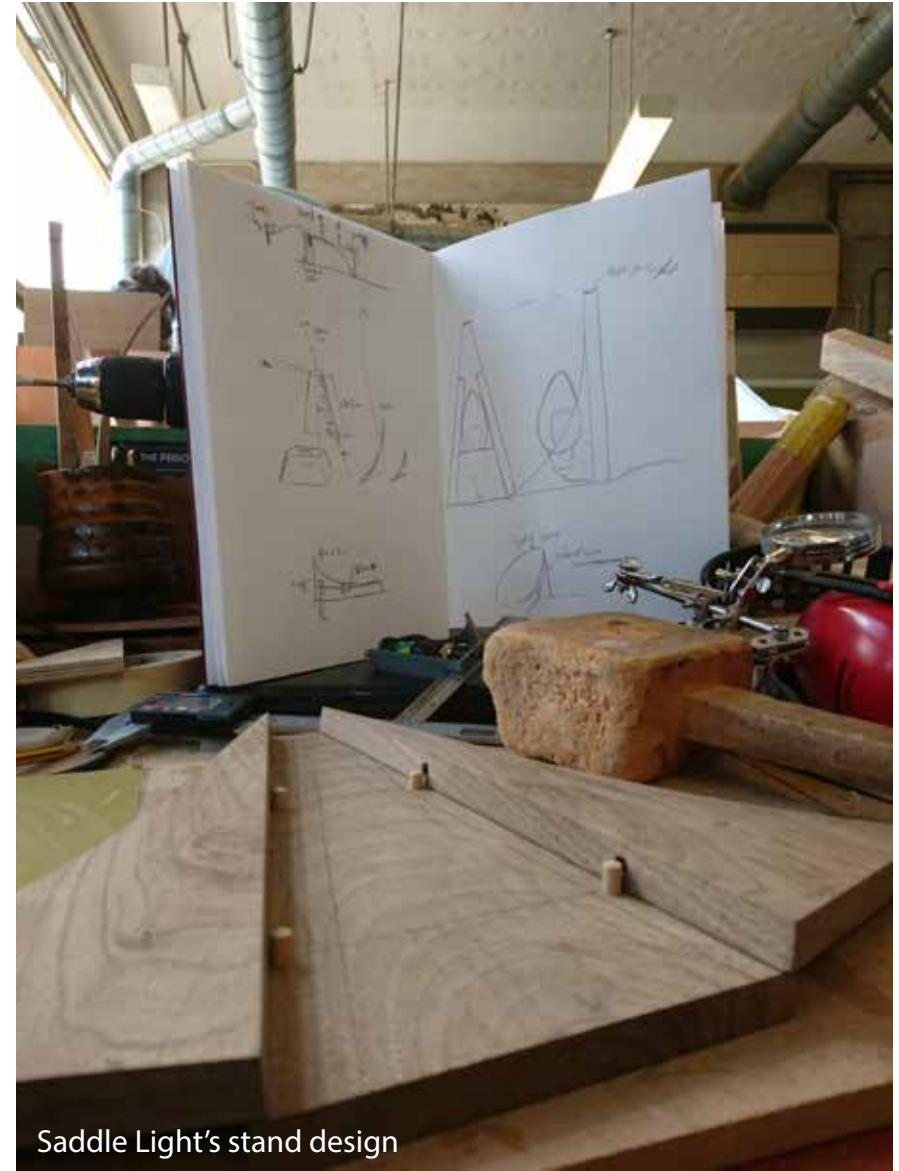
Translucent Ash



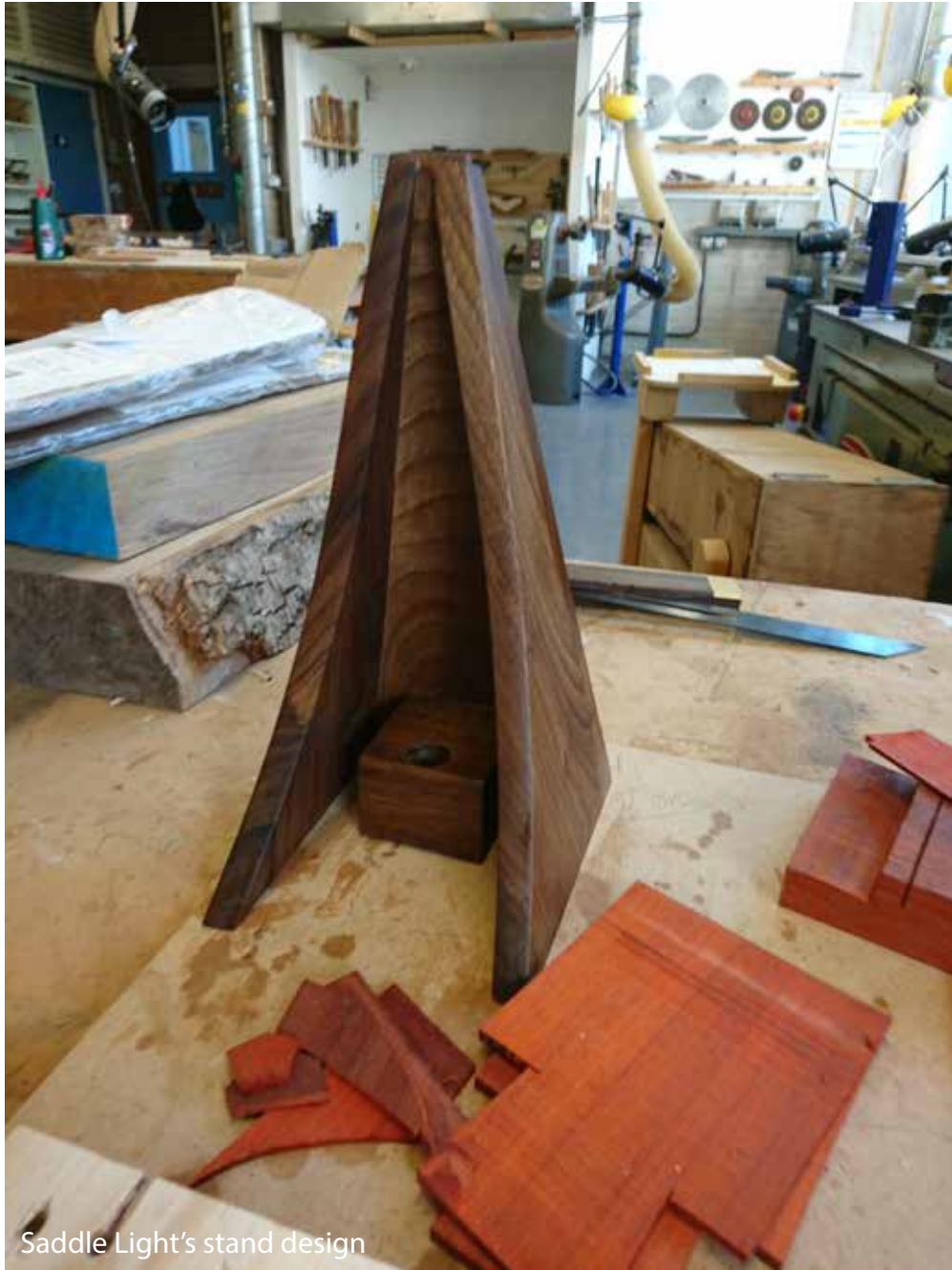
Saddle Light mounting



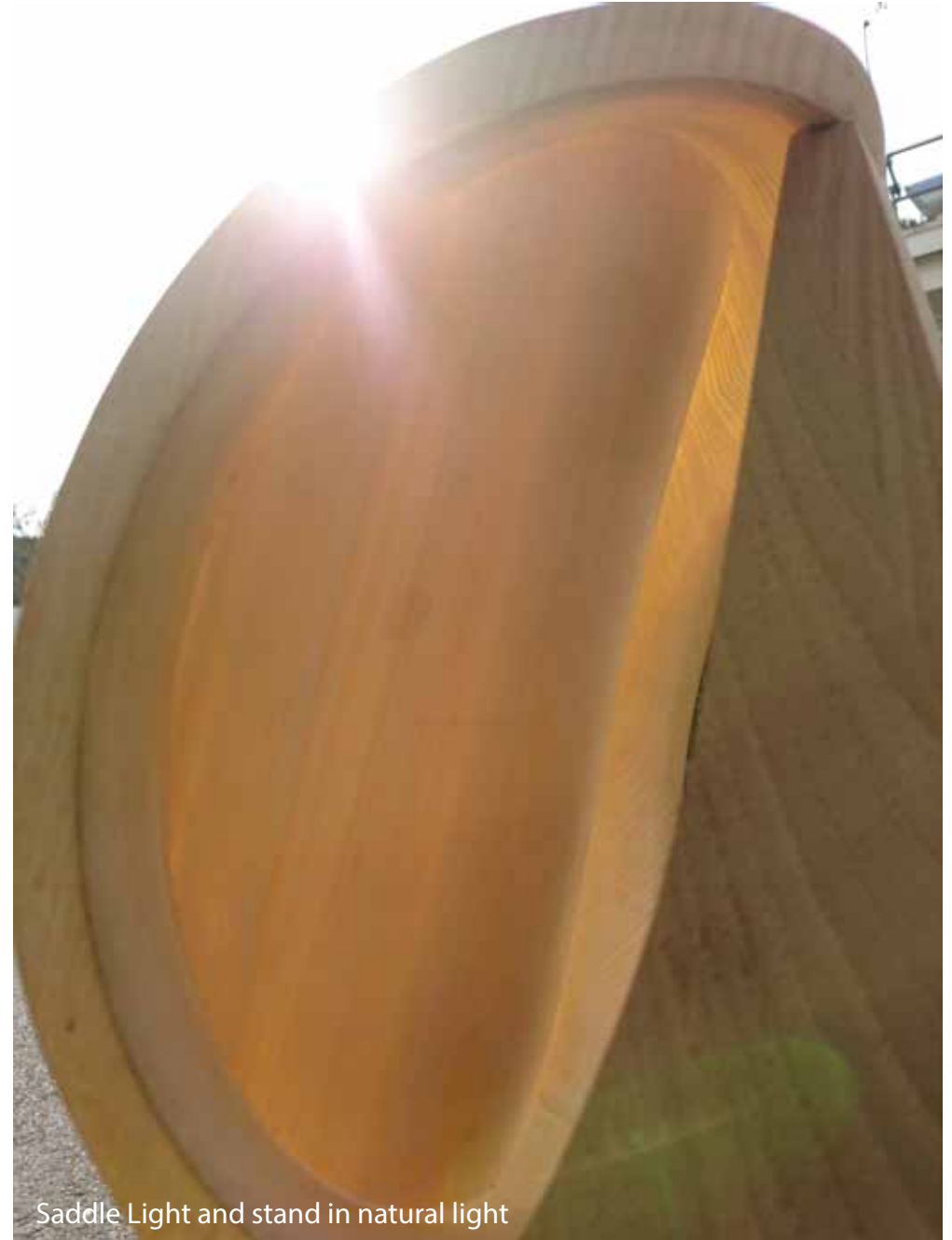
Saddle Light mounting



Saddle Light's stand design

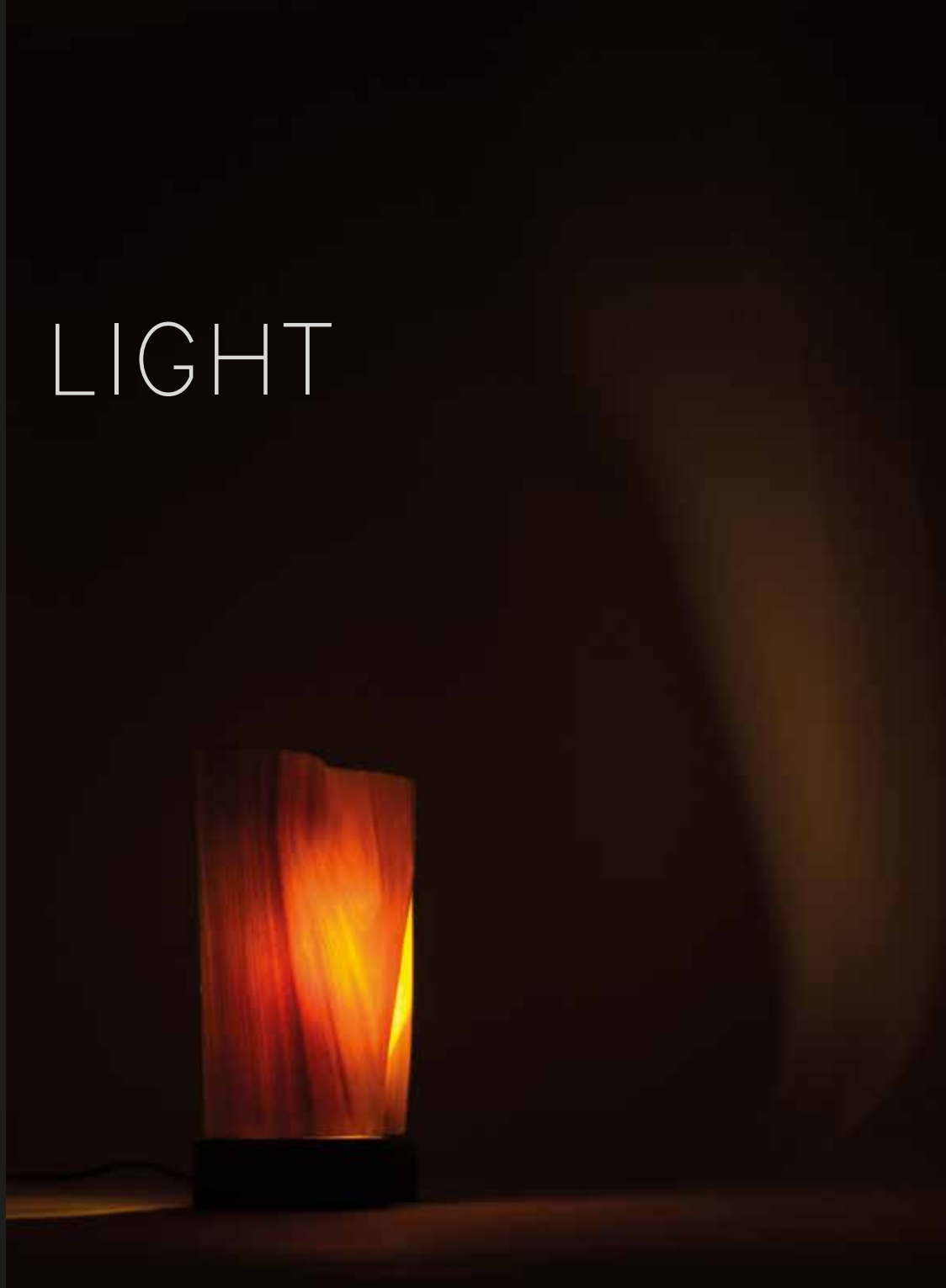


Saddle Light's stand design



Saddle Light and stand in natural light

SPIRIT LIGHT





The spirit light was made from 2 carefully selected and cut Ash wood panels from the photograph above. The panels went through the same process as the saddle light and emits a warm ambient light, with colours representative of candle or fire.

After selecting the panels that turned out the best for this design, I then made the base to fit them, adding a small feature that allows the bulb to be changed by removal of one or both of the panels.





Light testing the Ash panels



Walnut base



Ash panels in natural light



Close up of the base



BONE LIGHTS



Bone lights delignified



Bone light internal view



Bone light, scorched robinia and padauk



Robinia rose on the lathe



Bone light light test

The Bone Lights were made from green ash, a log turned on the lathe then cut into 3 and bored out individually. These lights hang from Padauk and scortched Robinia creating a colour match similar to one i discovered earlier in the year when experimenting with veneer samples.

The cables are adjustable and the ceiling rose connects to a standard main-splug for ease of instalation during exhibition setups.

These lights are less translucent but contain plenty of charecter from the detail in the wood acumpanied with a vivid red glow.



Bone lights assembly

PANEL LIGHT





Delignified Olive Ash panel

Unfortunately the panel lights translucent panel snapped a couple of days ago leaving me less than a week to design and make a new light, different to the lights seen in the render on page 45 as they're from the previous design. The two pieces of Olive Ash separated along the path where the colour changes, it has a nice organic natural curve which I am now using as a feature in the new design.



Olive Ash bleached panel



Panel drying

The most difficult part of this process was trying to keep the wood as straight as possible. I selected the and cut the wood carefully for hope of the least warping expecting only minimal curves.



Panel early drying



Panel snapped





Me turning Robinia on the lathe with a diamond parting tool

TURNING

Developing my wood turning skills was important due to the forms I wanted to produce. I worked hard to progress my turning skills further throughout the entirety of the Lignum Lux project, I did this by going over the basics and then expanding my skills with difficult woods and forms. I discovered bowls, hollow forms sharpening and pen making, developing these skills allowed me to feel more comfortable using different tools and understanding how they attack the wood in conjunction with the woods grain direction and hardness.

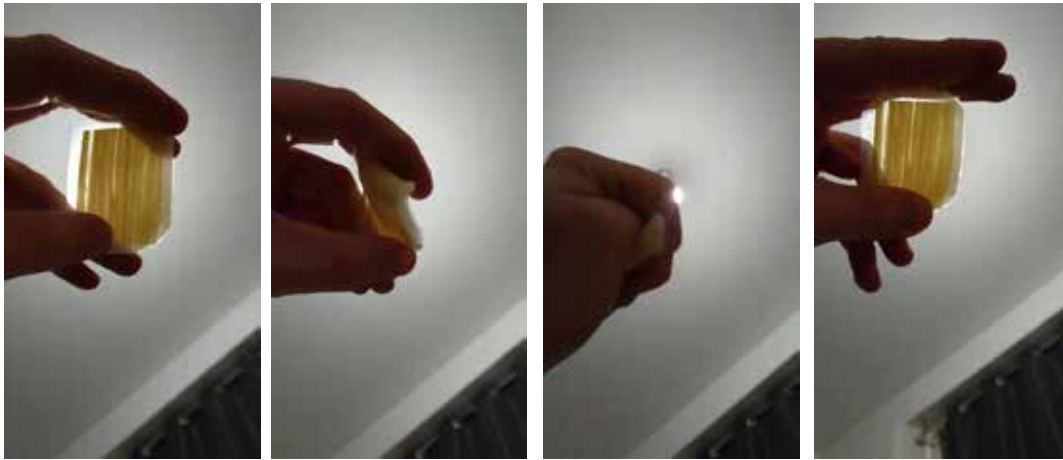


- Robinia pseudoacacia (Black Locust)



- Horse Chestnut Burl (Aesculus hippocastanum)

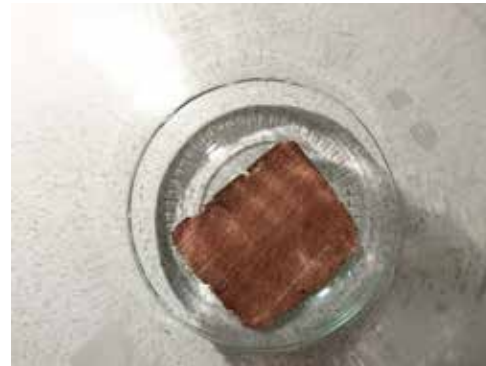
DISCOVERIES



Crushable wood sample



Driftwood sample



Driftwood sample in solution

Although Lignum Lux is based around the translucency and warping of the wood, there were even more discoveries along the way too:

First of all, I successfully made translucent wood followed by lots of mistakes and lots of learning. But all this got me researching and experimenting more, I then produced translucent sheet leaf material (page 5), followed closely by crushable translucent veneer, and finally the spring effect produced by some of the early processes.

More recent, I had an idea about drift wood and salt water which could potentially produce interesting light results. I figured, the salt cleans out the vessels of the wood, creating a clear path of light. With more research I discovered that when the driftwood dries, the salt crystals expand in between the wood fibres which creates the 'fluffy' effect you see on drift wood. With the addition of an environmentally friendly solution the wood becomes more translucent and with a sparkley/glitter like effect where the light can be seen directly through the empty and expanded vessels.

Wood oils like Tung also increase the translucency if applied correctly to the dried and finished wood lights.

CAD RENDERS



Panel light variation



Panel light variation



Saddle Light variation



Saddle Light variation



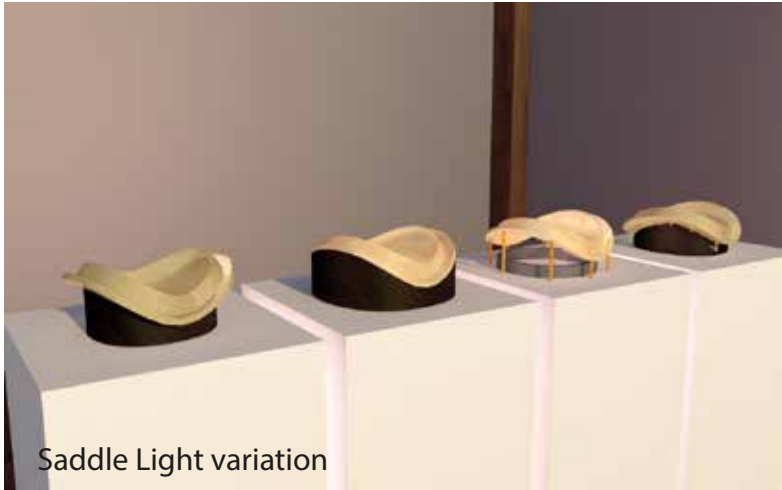
Saddle Light, wood and copper



Saddle Light variation



Saddle Light variation



Saddle Light variation

SUMMARY

Wood samples have been manipulated through a series of experimental processes with various new outcomes, each giving the wood new properties to design from allowing new applications for wood as a material. The elegant warping and translucency of the wood are made possible by the manipulation of the ultrastructure and can create a warm natural light which creates a feeling of calm, like that of a controlled flame.

I plan to continue to investigate wood as I feel the Lignum Lux project is only a small portion of the potential that this project has. In the near future I plan to use my research to develop interior design, sculptural and structural applications.



Photo of me collecting the spalted Beech burl on page 47.