

*Equitable
and sustainable composites for
the future*

Professor Steve Eichhorn
Bristol Composites Institute
Annual Conference

9th November 2021

bristol.ac.uk/composites

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We live in confusing times!

Climate > News

Insulate Britain protester speechless after TalkRadio host says concrete can be grown on trees

Exchange comes as climate group threatens major disruption on M25

Matt Mathers | 15 hours ago | comments



Irish Examiner

New 'robot trees' installed on Cork City streets

The high-tech 'trees' take in particulate matter but have been criticised as a 'costly and ineffectual gimmick'



The first of five high-tech 'CityTrees', aimed at combating fine dust particle pollution and other pollution associated with traffic congestion on Cork City's Patrick Street. Photo: Cork City Council



Climate Change – The Implications

- “The Paris Agreement is a global treaty under the UNFCCC adopted in 2015. It aims to keep the global average temperature increase well below 2°C warming compared to pre-industrial levels and pursue efforts to keep it to 1.5°C.
- We are already experiencing devastating impacts at only 1°C warming. A 2018 special report by the Intergovernmental Panel on Climate Change has made it clear that increases of more than 1.5°C would be absolutely catastrophic.
- Yet countries’ pledges to reduce their emissions under the Paris Agreement [currently fall far short of the 1.5°C or even the 2°C target](#). The Glasgow summit will be an important opportunity to put pressure on big and historical polluters, including the UK, EU and US, to do their fair share and increase their climate targets.”

- Friends of the Earth – Scotland, 2021

<https://foe.scot/press-release/updated-paris-pledges-leave-world-on-track-for-climate-catastrophe/>



Stop burying our heads in the sand

Extreme Weather Events

Selected Significant Climate Anomalies and Events: July 2021

GLOBAL AVERAGE TEMPERATURE

July 2021 average global surface temperature was the highest for July since global records began in 1880.



ARCTIC SEA ICE EXTENT

July 2021 Arctic sea ice extent was 18.8% below the 1981–2010 average — the fourth-smallest July extent since satellite records began in 1979.

NORTH AMERICA

North America had its sixth-highest July temperature on record.

CONTIGUOUS UNITED STATES

Much of the West and northern Plains had above-average temperatures during the month, with several states having their warmest July on record. Meanwhile, below-average temperatures were present across parts of the East and South-Central U.S. Overall, this was the 13th-warmest July (tied with 1954 and 2003) on record for the nation.

HURRICANE ELSA

Elsa was the earliest-forming fifth named storm in the Atlantic Basin.

SOUTH AMERICA

Above-average conditions were present across much of the continent, resulting in the 10th-warmest July on record.

EUROPE

Europe had its second-warmest July (tied with 2010) on record, behind 2018. Several locations across southern Europe were affected by a heat wave that brought temperatures above 40.0°C (104.0°F) at the end of the month.

ASIA

Asia had its warmest July on record, surpassing the previous record set in 2010. Nine of the 10 warmest Julys in Asia have occurred since 2005.

AUSTRALIA

Australia had its fourth-warmest July on record. Regionally, South Australia, Western Australia and the Northern Territory had a top-three warm July.

AFRICA

Africa's July 2021 temperature was the seventh-warmest on record.

GLOBAL CYCLONE ACTIVITY

The January–July tropical cyclone activity was above normal for named storms.

ANTARCTIC SEA ICE EXTENT

The Antarctic sea ice extent for July 2021 was the largest July sea ice extent since 2015 at 2.6% above average.

Please note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: <http://www.ncdc.noaa.gov/sotc>

<https://www.ncdc.noaa.gov/sotc/global/201913>



Floods



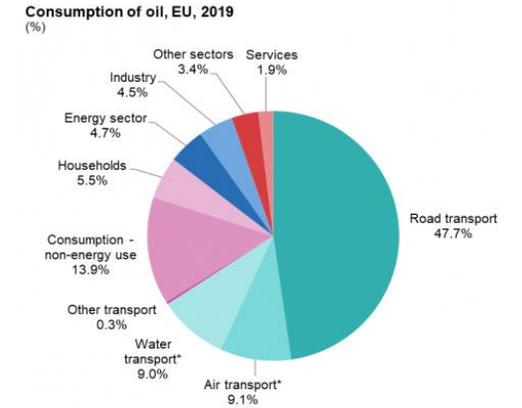
Forest Fires



Biodiversity loss

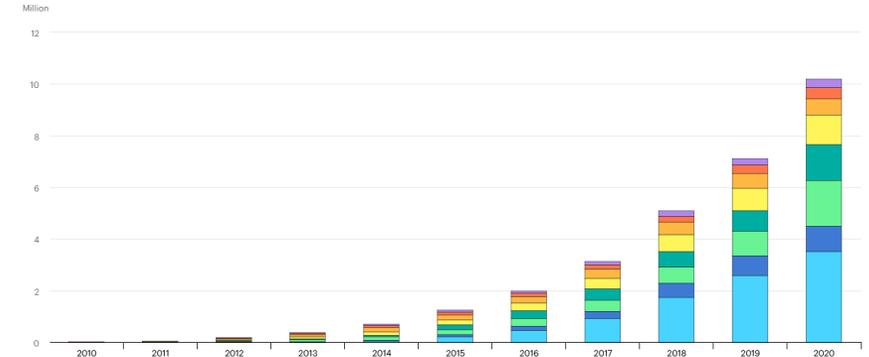
The Problem with Our Materials Cycle

- We currently get most of all of our materials for composites with a reliance on oil.
- “research from Stanford University finds that in 2015, nearly 9,000 oilfields in 90 countries produced greenhouse gases equivalent to 1.7 gigatons of carbon dioxide – roughly 5 percent of all emissions from fuel combustion that year” – Stanford News ([Measuring crude oil’s carbon footprint | Stanford News](#))
- “total emissions from crude oil production may be higher than even these latest calculations suggest, because the current analysis does not fully capture emissions related to leakage and venting of **methane**, a powerful global warming gas” ([Measuring crude oil’s carbon footprint | Stanford News](#))
- There is a drive to decarbonise energy, to reduce our reliance on petroleum.
- The divestment in fossil fuels is increasing – slowly, but increasing!
- The only reason why we make plastics from oil is a convenience on the back of oil production for fuel



Note: Consumption for non-energy use includes the non-energy consumption of fuels in the transformation, energy, transport, industry, and others sectors
(*) includes domestic and international voyages
Source: Eurostat (online data code: nrg_bal_e)

eurostat



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<https://www.iea.org/reports/global-ev-outlook-2021/trends-and-developments-in-electric-vehicle-markets>

The Future – What is Sustainable?

Sustainable development is development that meets the needs of the present without compromising the needs of future generations to meet their own needs (Bruntland 1987)

“The fact is that we live in a world that has been profoundly shaped by empire and its disparities. Differentials of power between and within nations are probably greater today than they have ever been. These differentials are, in turn, closely related to carbon emissions. The distribution of power in the world lies at the core of the climate crisis”

Ghosh “The Great Derangement: Climate Change and the Unthinkable. Chicago, IL. University of Chicago Press.



Solomon Islands



Flooding in India

- Non- renewable



Oil



Coal



Natural Gas

- Renewable



Timber



Plants



Wool

- Replenishable



Water

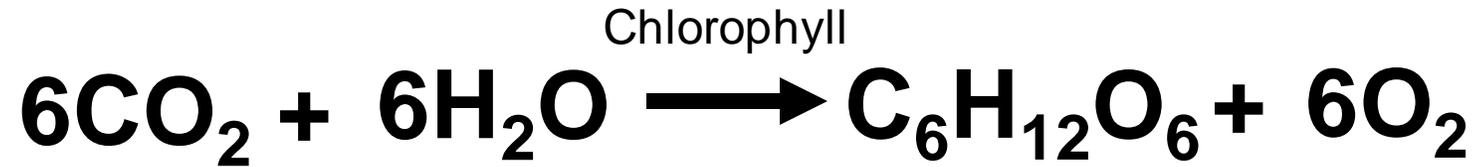


Soil



Air

Cellulose – Nature's Wonder Material



Spring



Summer



Autumn



Winter



The word 'material' derives from an old Latin word *māteria* for 'trunk of a tree'

This derives from the word *māter* which means 'mother' – "Mother Earth"

Trees near Avebury Stone Circle, November 2016

- Carbon capture
- Biodegradable
- Sustainable
- Structural
- Clean air
- Cooling
- Calming
- Living

What can we produce from biomass?

- Paper
- Plastics/polymers
- Fuels
- Carbon fibres

What about returning to a biomass based economy?

- **Composites**
- **Batteries**
- **Filtration media**
- **Solar cells**
- **Biomedical implants**



Foster *et al.* (2018) Chem Soc Rev: **47** 2609-2679

But what about the trees?



Grow More Trees!

BBC Stephen Eichhorn Home News Sport Weather iPlayer Sounds

NEWS

Home Coronavirus Climate UK World Business Politics Tech Science Health Family & Education

Wales Wales Politics Wales Business North West North East Mid South West South East Cymru Local News

Climate change: 'More homegrown timber needed' to cut emissions

By Steffan Messenger
BBC Wales Environment Correspondent

4 days ago

Climate change



Woodland covers just 15% of the land in Wales

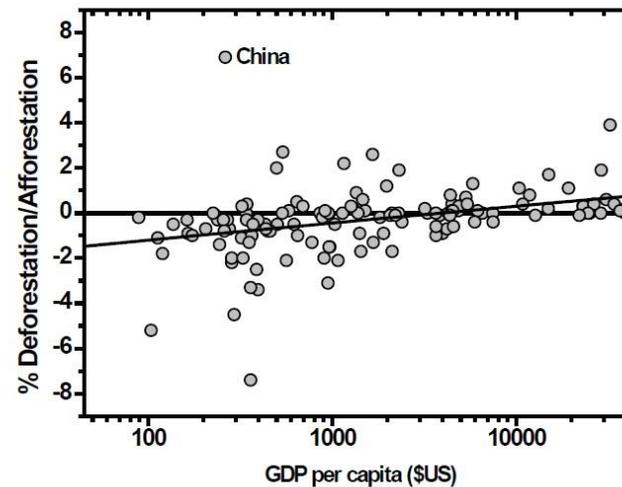
Building the homes of the future will require Wales to become a "forest nation", according to industry experts.

[Climate change: 'More homegrown timber needed' to cut emissions - BBC News](#)



Great China Green Wall

4,500 km area of 100 billion trees in Northern China to prevent desertification (Gobi Desert)



Callum Hill "An Introduction to Sustainable Resource Use" (Earthscan)

"The Prime Minister made a manifesto pledge during the 2019 general election to plant more than 30,000 hectares (75,000 acres) of trees a year by 2024, in a bid to reach net zero by 2050." – iNEWS [Boris Johnson's tree planting pledge branded 'humiliating failure' as number of trees planted falls \(inews.co.uk\)](#)

The number of trees planted in the UK actually fell last year (2020).

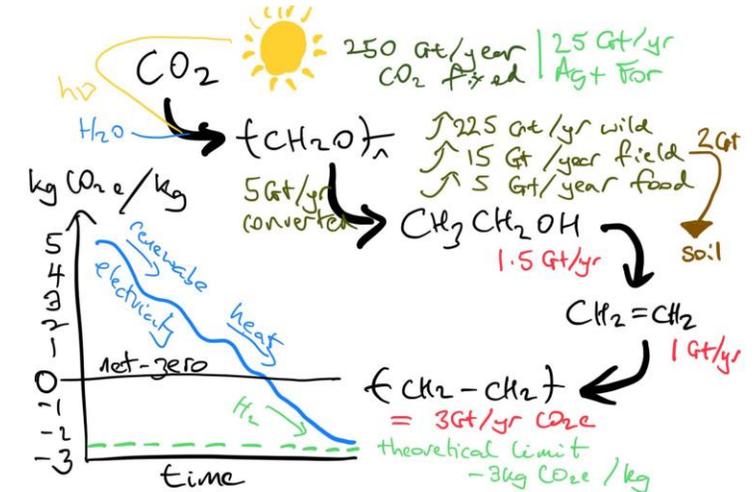
But what do we do with converted biomass?



[Wind Turbine Blades Can't Be Recycled, So They're Piling Up in Landfills - Bloomberg](#)



Prof. Tony Ryan
OBE (Sheffield)



"All our work on the plastics circular economy has made me think we need to turn the problem on its head. Make more single use plastic but using C that has been fixed by photosynthesis and taken from the atmosphere this year, **not C fixed millenia ago**. Neo-carbon not fossil-carbon to turn into neo-fossil plastic and put it back in the ground.

If we do it I really do think we could **sequester a gigatonne of carbon dioxide a year** once we have decarbonised heat.

It could turn plastic consumption into a good thing, the environmental benefits of plastic (reduced food waste being one example) could be maintained.

The petrochemicals industry could continue **to benefit from its capital assets and be persuaded to leave the oil & gas in the ground** if it could see a profit from a "consume then conserve" plastic policy.

When plastic sequesters carbon from the atmosphere by being made from biomass it makes sense to use it to replace even more materials. For example **carbon fibre composites (where both the fibre & the resin were neo-carbon) could replace lightweight metals in transport and steel in construction.**"

What will happen to our waste though?

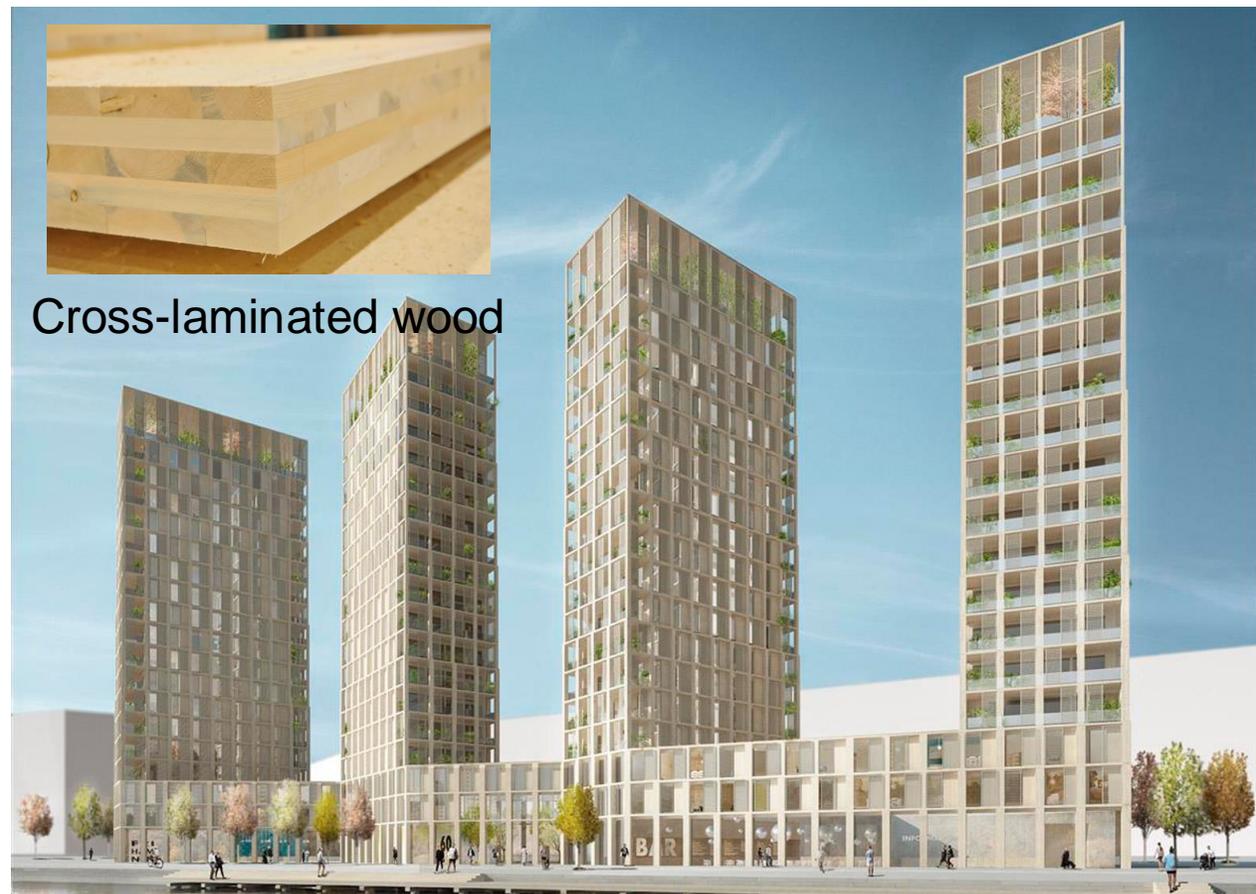
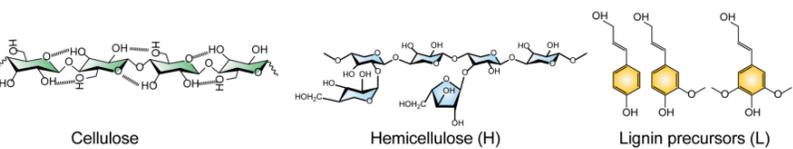
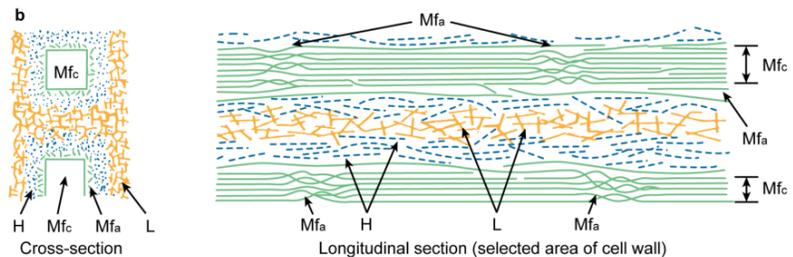
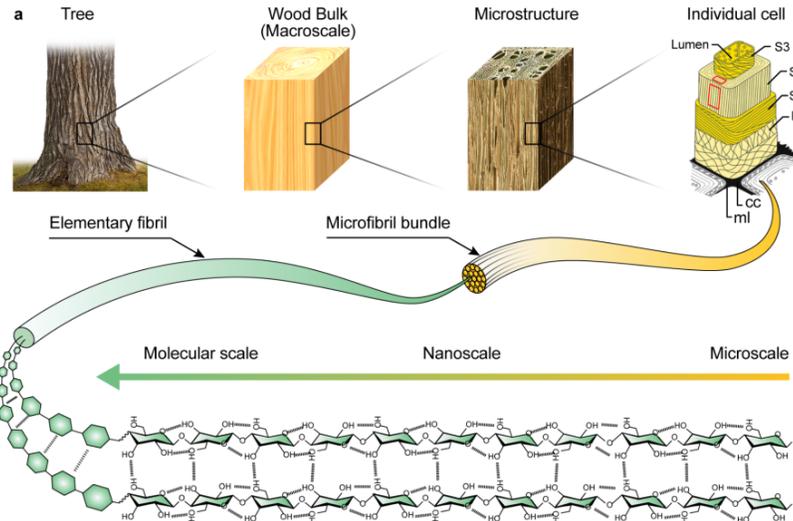


['Treated Like Trash': What UK Recycling Systems Teach Us About Waste Colonialism - Eco-Age](#)

- In 2018 China announces an import ban on foreign waste.
- The UK exports a significant amount of domestic and industrial waste to overseas countries (e.g. India, China, and Malaysia, Indonesia and Vietnam following China's ban).
- Nuclear waste has been dumped off Somalia in clandestine ways since the 1980s.
- **What will happen to the next generation of material waste?**
- **We need equitable waste management.**

The Case for Wood

Wood's hierarchical cellular structure



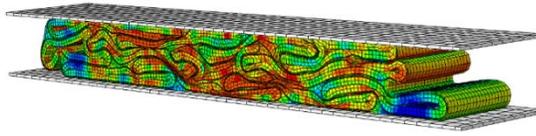
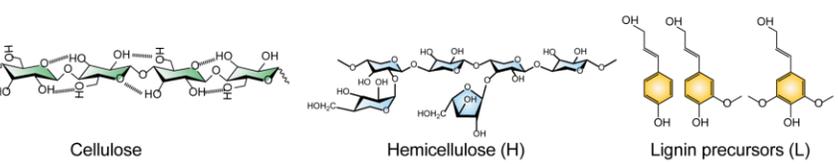
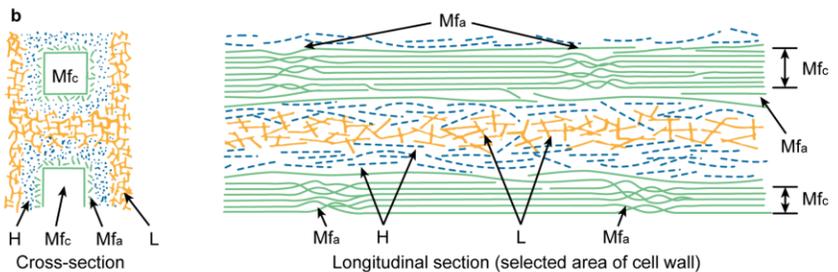
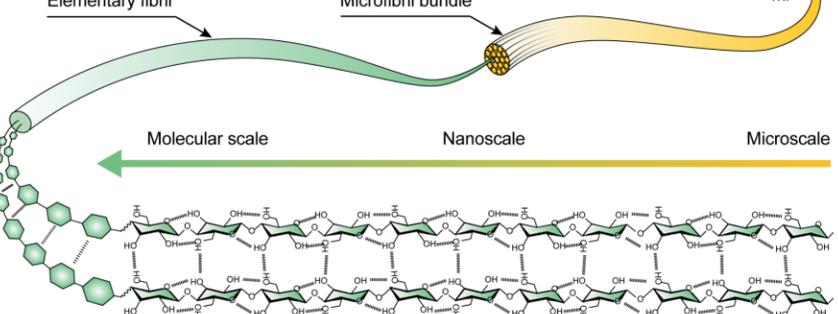
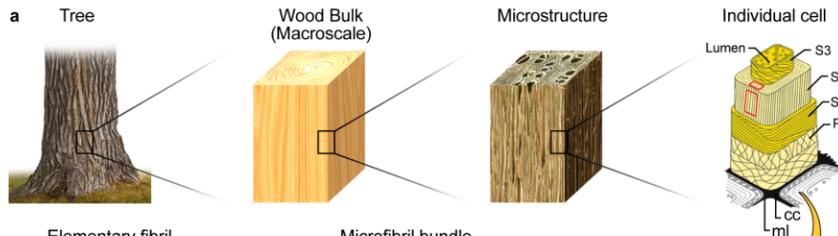
Cross-laminated wood

‘Architects embrace “the beginning of the timber age”
Tham & Videgård’s vision of skyscrapers in Stockholm

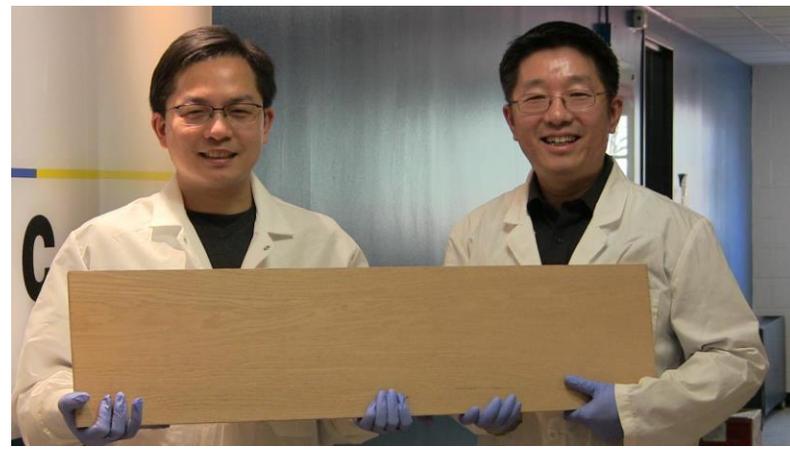
Chen *et al.* “Structure-property-function relationships of natural and engineered wood” *Nature Reviews Materials* 5 (2020): 642–666

Back To Wood

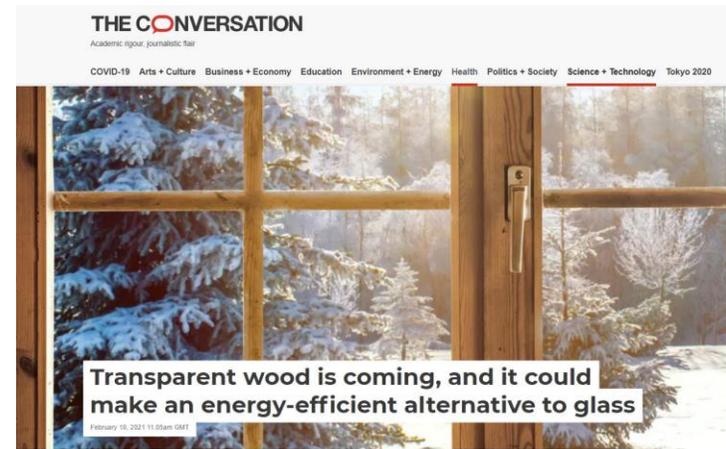
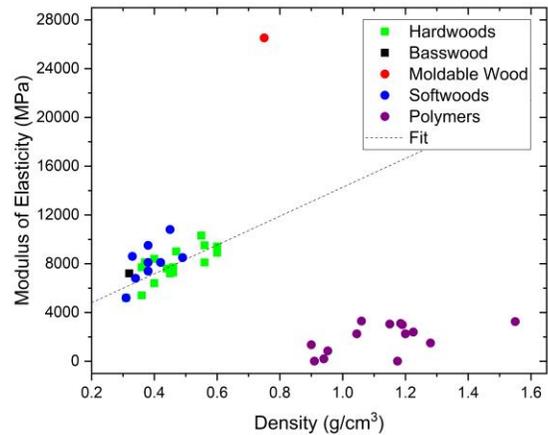
Wood's hierarchical cellular structure



Yan, Eichhorn & Toumpanaki - submitted



Liangbing Hu and Teng Li (Maryland)



Chen et al. Nature Reviews Materials, 5, 642–666 (2020).



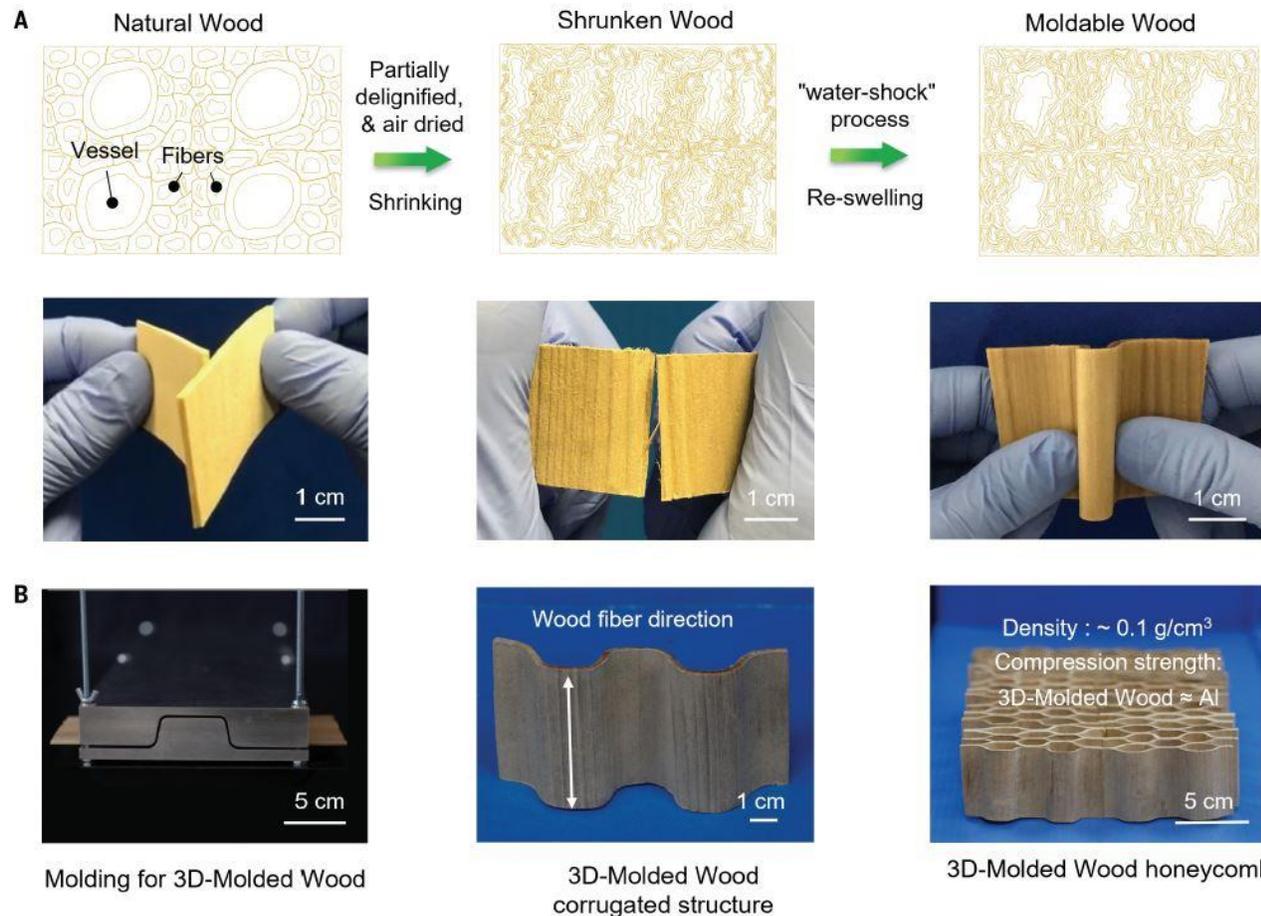
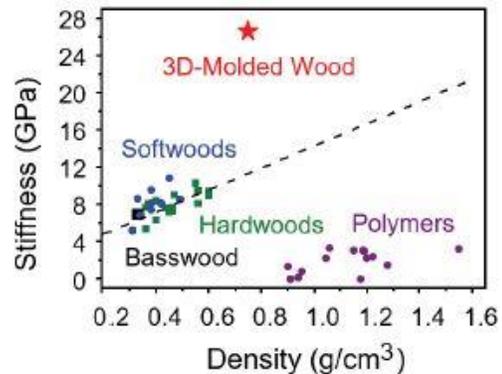
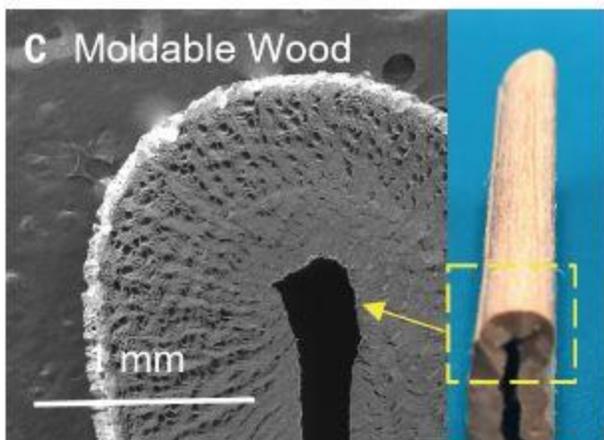
Moldable Wood

REPORT

STRUCTURAL MATERIALS

Lightweight, strong, moldable wood via cell wall engineering as a sustainable structural material

Shaoliang Xiao^{1†}, Chaoji Chen^{1†}, Qingji Xiao^{1†}, Yu Liu^{1†}, Yuan Yao², Qiongyu Chen³, Matt Hartsfield⁴, Alexandra Brozena¹, Kunkun Tu⁵, **Stephen J. Eichhorn**⁵, Yonggang Yao¹, Jianguo Li¹, Wentao Gan¹, Sheldon Q. Shi⁷, Vina W. Yang⁸, Marco Le Riccio⁸, J. T. Zhu⁸, Ingo Burgert⁵, Alan Luo⁴, Teng Li³, Liangbing Hu^{1,9*}



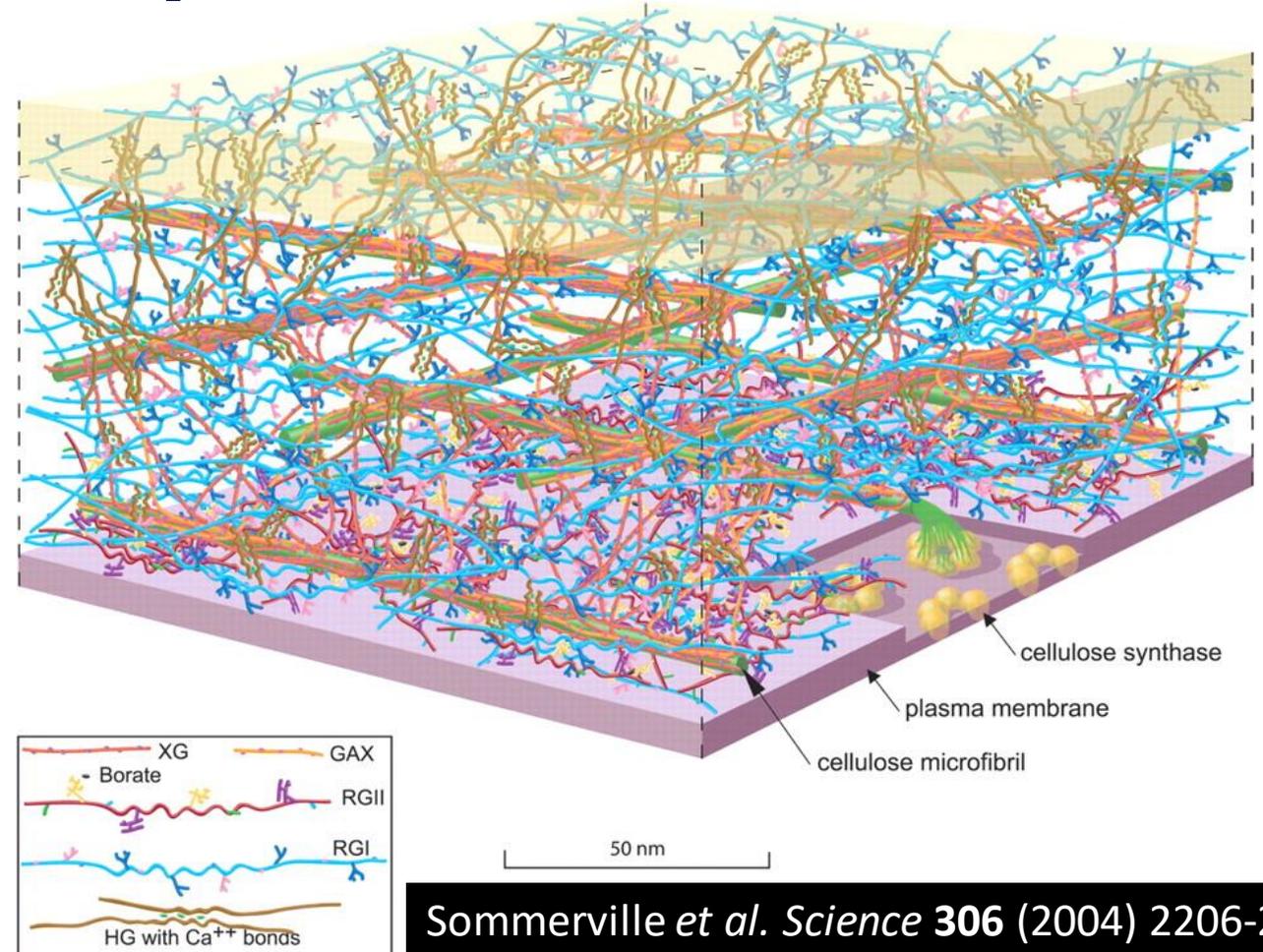
Xiao *et al.* *Science* – 22nd October issue (front cover)

Science
AAAS

EPSRC Fellowship – “Realising Functional Cellulosic Bio-Based Composites”

Five year programme (2021 – 2026) £1.6m, funded by the EPSRC giving me 50% time to devote to research, and ED&I activities.

- Project aims to take inspiration from how cellulose assembles in the cell walls of plants and to try and replicate that in synthetic systems.
- Take concepts of amphiphilicity of cellulose and develop motifs and complexes that can assemble to make functional materials.
- Looking more broadly at water interactions of cellulose



Sommerville *et al.* *Science* **306** (2004) 2206-2211

EPSRC ED&I Fellowship in Physical Sciences

- 2017 surveys indicate 11% of the engineering workforce is female.
- UK has the lowest percentage of female engineering professionals in Europe, at less than 10%.
- 15.1% of engineering undergraduates in the UK in 2017 are women.
- “In 2017, there were just 3 female professors. According to the Higher Education Statistics Agency (2017), universities are more likely to employ Black staff as cleaners, receptionists or porters than as lecturers or professors.”*
- **More than 70% of people** teaching in British Universities are “white men” (2016/17 HESA statistics).

Fewer than 1% of UK university professors are black, figures show

Among 21,000 academic staff at professorial level only 140 identify as black, Hesa says



Centering Black Scholarship



▲ Oxford was one of the few UK universities to employ enough senior black academics to show up in the official statistics. Photograph: Getty Images/iStockphoto

Fewer than 1% of the professors employed at UK universities are black and few British universities employ more than one or two black professors,

5 year programme of...

Training

Outreach

Culture
change

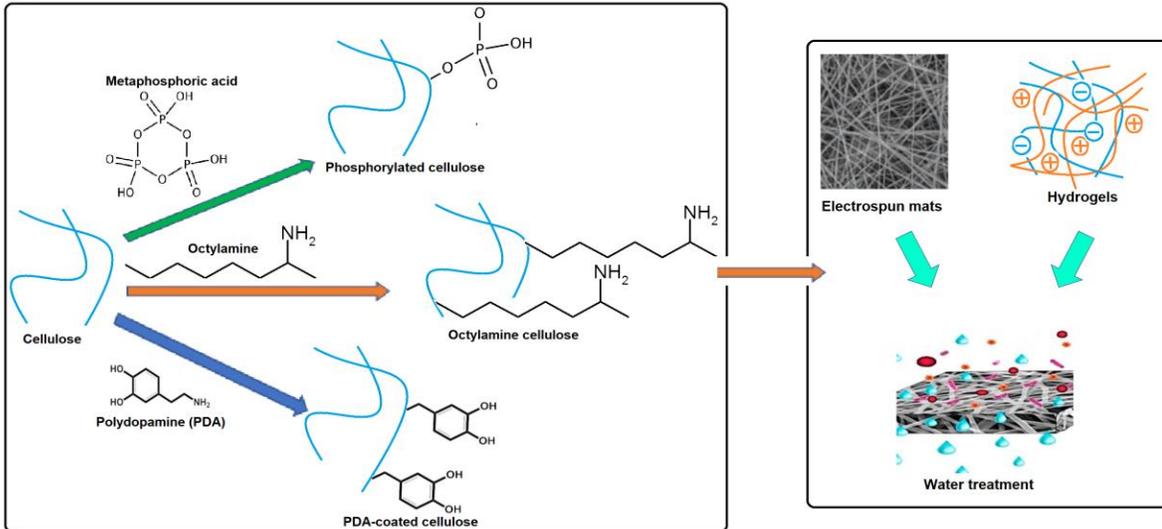
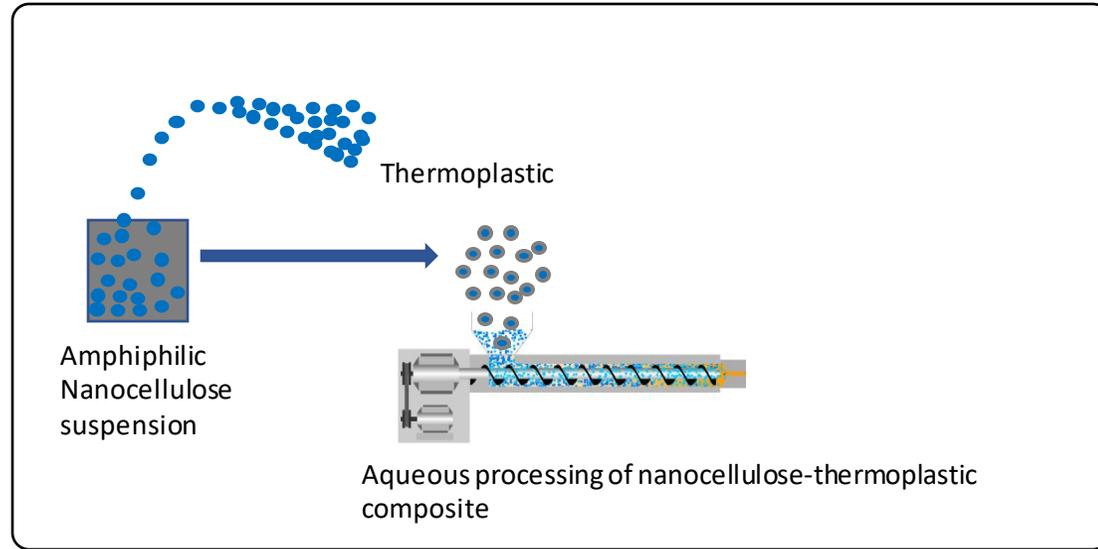
Recruitment

* Begum & Saini “Decolonising the Curriculum” (2019) Political Studies Review
[ps://doi.org/10.1177/1478929918808459](https://doi.org/10.1177/1478929918808459)

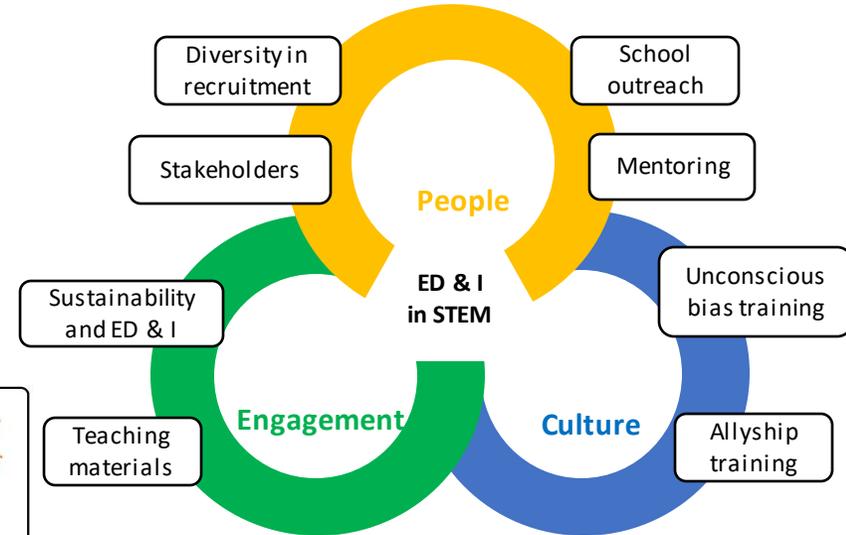
PSRC ED&I Fellowship in Physical Sciences



Dr Amaka Onyianta



Dr Anita Etale



Thank you for listening!

