BRANCHING OUT

The nanotechnology in trees

My name is Jess Wade. I am a physicist – a nano-scientist, to be precise, and I'm here to talk to you about trees.

When was the last time you looked at a tree? I mean *really* looked. The intricate structure of bark, the super smooth branches, the fragile leaves. Trees are truly remarkable things: they can be taller than tower blocks, provide homes for birds and insects, store rainwater and protect us from harmful pollution in the atmosphere.

Magic materials

Humans have relied on trees for millions of years. We sharpened sticks into spears. We turned timber into homes and built wooden cranes to lift heavy objects. We took whatever we could find from the world around us and transformed it until we'd turned it into something useful. Since then we've done the same thing with lots of different materials: from clay, we made huts; from wool, blankets; from stone, statues. We've even discovered new materials by mixing together and taking apart old ones. We turned sand into glass, oil into plastic and limestone into mortar, but we've always worked from the top down – figuring out what we can make from the materials we find.

From ~~tiny~~ atom-sized acorns

Recently, in labs around the world, scientists have been experimenting with a very different idea; one that is transforming how we create new technologies, construct our homes and synthesise medicines. The idea is this: what if, instead of starting with something huge like a tree, we begin with the universe's smallest building blocks and end up with something mind-blowingly massive? **What if we worked from the bottom up?**

Nanotechnology is giving humans the power to make things that – not too long ago – seemed like the stuff of daydreams. To wrap your head around nanotechnology, let's first think about **atoms**: the building blocks that make up everything on the planet. Even the tiniest things we can see contain more atoms than we could ever count. We've discovered 118 different types of atom, and each of these is called an **element**. Over 90 of these elements are found in nature, and the rest we make in science labs.

The atomic generation

You are alive at a unique time in human history. You're part of the first generation that not only knows about atoms, but also knows how to look at them one by one, pick them up and move them. When you're working at such a tiny scale, it's called nano-science. Just how small is the nano-scale? A nanometre is a billionth of a metre (which is *really*, really small). It's the distance your fingernail grows in one second.

In materials and molecules, atoms join together to form all sorts of patterns. There are hexagons and cubes, pyramids and cylinders, spirals and spheres. These patterns are very important, because they give a material its **properties**.

Cross-section of heartwood (central supporting pillar) of the oak *Quercus robur*, using an electron micrograph. The largest vessel is actually 0.3 mm in diameter.

The patterns are much too small to be seen with just our eyes, or even with a magnifying glass or microscope; so we've built new machines to study them. We have to use a really special kind of microscope; one that doesn't use light at all. Instead, these machines scan a material's surface using a beam of high-energy electrons (charged sub-atomic particles). When electrons hit the material they lose energy, which is converted into heat, new electrons and light, all of which provide detailed information about the properties of the material's surface. By matching these signals with the precise places where they were measured, the electron microscopes create ultra high-resolution maps.

For example, when we collected images of frozen pieces of wood, we found that the atoms had arranged themselves into intricate molecules, which assembled into cylinders several nanometers long. This may help to explain why wood is so strong and flexible. It might also help us to understand its limitations – such as why wood splinters or warps.

Barking up the right tree

By understanding the arrangement of atoms inside wood we can begin to engineer new types. Imagine wood that could rival even steel and concrete for strength and durability! Can you picture a whole city of wooden skyscrapers: where our tallest towers protect the planet instead of causing it harm? It's my job to study and control the patterns of atoms. People like me spend our days trying to create useful things, atom by atom, in order to build a better world for everybody living in it.

FUN FACT TRUMPET

You could fit 10,000,000 (that's TEN MILLION!) atoms side-by-side in the full stop at the end of this sentence.

Illustration: Kaley McKean. Photo credit: Dr Jeremy Burgess/Science Photo Library