DISCOVERING DIMENSIONS

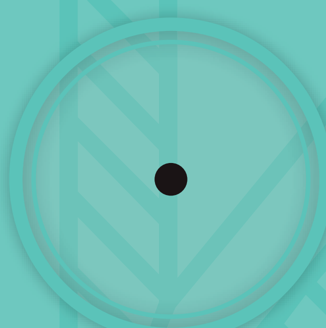
If you've ever seen science fiction, you're probably familiar with the idea of dimensions. They're different worlds in space and time with strange-looking creatures ... right? Well, not exactly. Greta Kite-Gilmour explains the nature of dimensions, and why they might be more useful than you think.

What is a DIMENSION?

The word 'dimension' can be defined in lots of ways. In maths and science, dimensions can be used to measure and interpret our universe. For example, we see the world and everything in it as having three dimensions, so we live in 3D. But, what would it be like to exist in a 2D world? Or even 1D?

Some scientists believe that our universe has ten, or even up to 26 dimensions. Although we can't see these dimensions, or move in them, we can use our current understanding of physics to imagine how our universe might appear in zero, one or more dimensions.

THE ZEROTH DIMENSION



0D POINT WORLD

For this journey, we start with a single point. Unlike the kind of dot point you might make with the tip of your pencil, the 0D point has no width, no height, no area and no volume. Inside a 0D universe, there is only one position.

What's the POINT?

You may be thinking, "What's the use of a space with no dimensions?" However, some major scientific theories rely on the idea of 0D spaces. Take, for instance, point particles.

Point particles have no shape, size or structure. If every single thing in our universe could be broken down into its smallest components, no matter what it was to begin with, we would always end up with these point particles – the tiniest subatomic particles believed to exist.

There are three basic classes of point particles: leptons and quarks (the 'building blocks'), which are pushed and pulled about by the equally odd-sounding bosons (the 'forces'). These classes are divided further into 16 specific types, including electrons (a type of lepton) and Higgs bosons.

Together, these 0D point particles form the basis of the standard model of particle physics – a theory used to explain and organise all the matter in the known universe, from tiny atoms to colossal galaxies.

THE FIRST DIMENSION

1D
LINE WORLD

We can imagine the first dimension as two 0D points connected by a single line running through them. This line has no width or depth, only length. If you lived in 1D space, you would only see one thing – whatever was directly in front of you. You couldn't move around it, because sideways doesn't exist. To see past that thing, you would have to destroy it!

Particle detectors, such as those at the Large Hadron Collider, record the movement of 0D point particles as straight lines and spirals.

Image: CERN

THE SECOND DIMENSION

2D
PLANE WORLD

Imagine you're in 1D space. Someone shows you a new direction, at right angles to the direction you already know. You can now move sideways, as well as back and forward. Welcome to the second dimension.

You'll be familiar with the second dimension, because it describes the flat surface of objects we encounter every day in our 3D world. This 2D space is referred to as a plane, and has length and width, but no depth. An example of a 2D plane is a typical map. Maps traditionally have a compass in one corner marking north, east, south and west. This can direct you forward and backward, left and right. However, it won't get you up a tree or down a hole!

A person experiencing the world in 2D would see this cabinet as a rectangle.

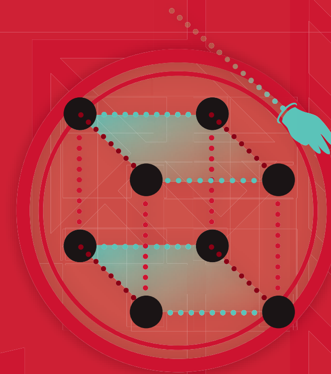
Life in 2D

How would the world look if you had length and width, but no depth? Imagine you are a completely flat drawing on the ground. You can still move around, but only along the surface of the ground.

You can't peel yourself up to sit in a chair or stand upright. You have no idea of what up or down even are! You only understand the idea of back and forth and side to side, and see only what exists in your flat plane.

Now, imagine a cupboard is placed on the floor next to you. You can't see the cupboard as we see it in 3D. You can only see the 2D bottom surface of the cupboard that touches the ground – that is, its width and length. So to you, it looks like a rectangle. The rest of the cupboard is hidden from your view, because it exists in the third dimension.

The Third Dimension



3D OUR WORLD

Once again, imagine you're in 2D space, and someone shows you a new direction. This direction is at right angles to every direction in 2D space, all at the same time. This new direction is called 'up'.

You can give your imagination a rest here – simply look around you! We experience our whole lives in 3D, because along with length and width, we also have a third dimension: height. Height gives us an extra direction of movement, allowing us to move up and down, as well as forward, backward, left and right.

Entering higher DIMENSIONS

Media that were once only found in 2D – including movies, prints and maps – can now have an added dimension. Check out these applications in 3D.

At the movies

In 3D movies, images appear to emerge from the screen. The 3D films you see at the cinema require glasses with polarised lenses. Each lens lets in light from a different angle. This allows the two 2D images projected onscreen to each pass through a separate lens. Your brain then merges the slightly different perspectives into one 3D picture, the way your eyes would normally see a 3D object.

CSIRO scientists can print intricate 3D shapes in titanium, such as these 3D printed bugs!

In print

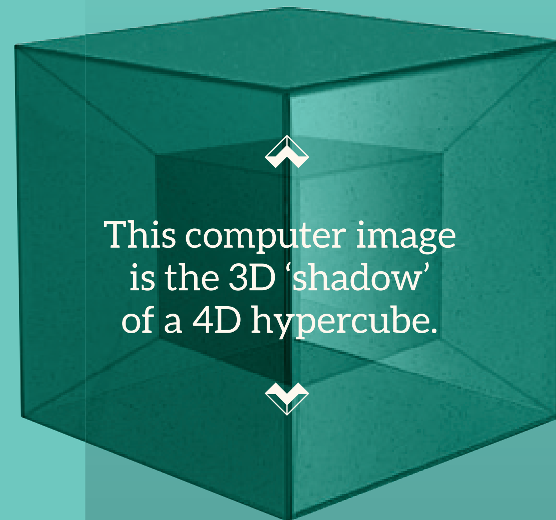
Objects can now be printed in 3D. Based on computer-designed models, 3D printers produce layer upon layer of thin material, such as a plastic or metal. The layers gradually build up to a final product. Scientists from the University of Wollongong aim to print human organs for transplants in the next few years, while one company in the United States is working towards printing edible meat!

Making maps

CSIRO recently developed 'Zebedee', a hand-held laser scanner that creates maps. This device scans an environment, creating an accurate 3D map in the time it takes to walk through the area. The map can later be viewed on a computer. The tool can map places that are usually tricky to capture, including caves, mines and smoke-filled areas.

Images: Mike McRae, Carrie/Clker, CSIRO

THE FOURTH DIMENSION



This computer image is the 3D 'shadow' of a 4D hypercube.

4D HYPERSHAPES WORLD

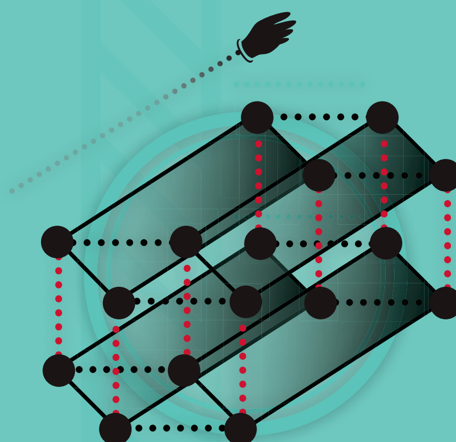
Here you are, a 3D person in a 3D universe. Or are you? Imagine a direction at right angles to every possible direction in 3D. This direction is called 'ana' and it is part of the fourth dimension.

Visualising our universe in less than three dimensions isn't too tricky – it involves familiar ideas about measurement and space. Understanding the fourth dimension, on the other hand, relies on concepts that exist outside of our everyday experience. Here are two ways you can think of 4D space.

Mathematically, the fourth dimension is explained using imagined shapes that have four spatial measurements. These are known as 'hypershapes'. In the same way we describe the surface of 3D objects as 2D, the surface of 4D hypershapes can be described as 3D. We can also learn a lot from imagining 'shadows' or 'projections' of 4D objects. In the real world, a 3D object has a 2D shadow – similarly, a 4D object has a 3D shadow!

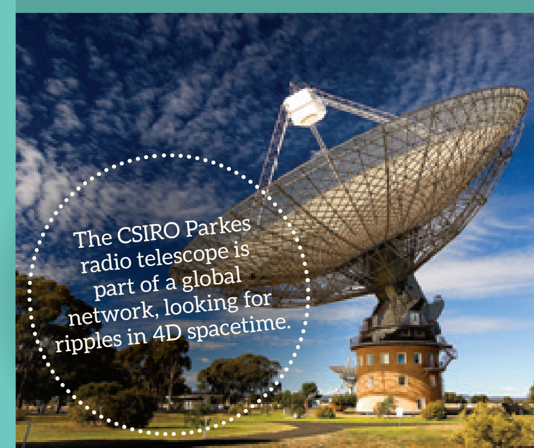
To picture ourselves in 4D, we use physics models, which involve time as the fourth dimension. Four-dimensional 'spacetime', first described by Einstein, explains space and time as an interconnected and ongoing invisible network.

We experience our lives in 3D, while travelling along a timeline within this network. We therefore can't see the fourth dimension, because we are moving through it.



We can imagine our lives as 4D 'snakes' containing images of ourselves at every moment.

If we could somehow view our own dimension from a higher one, our individual lives in 4D would look like a long stretch of images of ourselves at every point in our life: starting small as a baby, growing as you become an adult, and moving back and forth between school and home, snaking to every place you ever visit.



The CSIRO Parkes radio telescope is part of a global network, looking for ripples in 4D spacetime.

MORE-D?

Some current scientific models, including string theory and M theory, predict that up to 26 dimensions may exist. Scientists hope to better understand what these dimensions may involve over the next few decades. Some of the brain-bending theories being explored include alternate realities and compacted universes!

CSIRO's Parkes telescope is part of a global network set up to detect gravity waves. These are ripples of energy that – according to general relativity – warp the very structure of 4D spacetime as they travel through it! Elsewhere, CERN's Large Hadron Collider in Europe is on the lookout for particles predicted by higher-dimensional models.

Uncovering these additional dimensions may help solve problems in physics that have puzzled theorists since Einstein.