DARWIN'S DIGITAL CHILDREN

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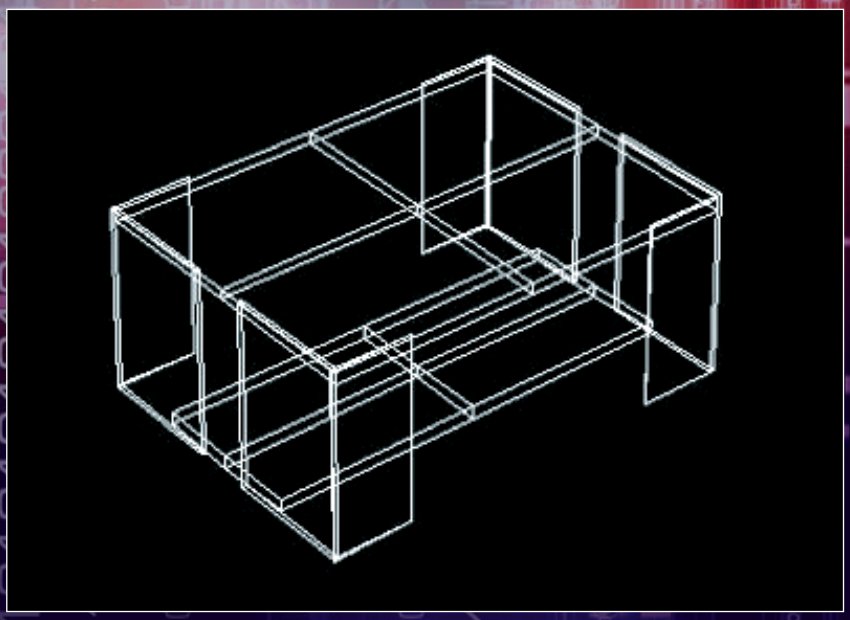
Computer scientists can use Darwin's ideas to make things evolve in a virtual world. Peter J Bentley, a computer scientist, describes how.

Darwin is famous because he changed the world. He explained life on our planet. He may have been born 200 years ago and his beard wouldn't win fashion awards, but his idea is just as valid today as it was back then. So if I were to choose a celebrity to meet, it would be Beardy Chas.

I'd like to think Darwin would be astonished if he were sitting next to me right now. OK, he'd probably be astonished at almost everything – the lights, the chairs, the computers – he lived a long time ago. But I'd like to think he would be more astonished when I told him that the coffee table his cup of tea now rested on was not designed by a human. It evolved. I think he would be equally surprised at what I would show him on my computer. I would show him **evolution** happening before his eyes.



The design for this coffee table was 'evolved' on a computer.

Evolution by computer

Perhaps you are thinking cynically, "Ah yes. He would show a computer game like *Spore*." Or perhaps you're thinking, "He would show a movie of something evolving like a cartoon or computer animation."

Nope. I would show him real evolution, happening by **natural selection**, the very same process that shaped all life on Earth. Happening live, in front of his eyes. Evolution that I do not control, and that I cannot predict.

I'd show him a view of a virtual world, with a colourful landscape. Virtual clouds would drift overhead, changing the light and the appearance of the colours as the virtual sun was obscured and revealed. He would see hundreds of little crawly things, eating parts of the landscape. As he watched he would see some die and disappear. "They've stupidly eaten something poisonous," I would explain. He'd see others coming together and producing baby crawly things. And as he watched he would see the population change in front of his eyes. Now the little critters can see where they are going – they have eyes! Now they can see what is good and bad to eat. Now they have formed strategies of movement – first they eat in one area, then they migrate to another area and let the first region regrow. Now some have discovered they can eat each other – there are predators and prey!

Then I'd show him another, different virtual world. This one has virtual water and we see strange twitching blobs floating about. As we watch we see that the better-swimming blobs have children; those that cannot swim so well have no children. Over time we see the shapes of these blobs change before our eyes. Generation after generation we see the shapes slowly morph into highly proficient swimmers. Some look amazingly familiar – there's something that looks exactly like a turtle with four flippers propelling itself along. Here's something that looks like a watersnake, spiralling its way through the water.

This virtual fish tank keeps evolving at the Boston Computer Museum.

Not a trick, not a game, not a fictional animated movie. These are scientific research projects that study evolution running on a computer. We call them Artificial Life, for obvious reasons. We don't tell them what to do, and we don't control them. Instead we create a virtual world containing food and hazards, and we add the magic ingredient – some simple self-replicating things. Then we watch what happens.

What makes evolution?

Evolution is a very simple process. You need **self-replication** (things that can make copies of themselves). The kiddies need to inherit features from their parents – so if the mother has a big head, the child may have a big head too. You need the occasional random **mutation** (perhaps the child has a bigger nose than either of its parents). And you need *selection* – something must ensure that some of the things survive longer than others, making them more likely to have kiddies, while others will die young and childless.

If you've got those things going on, then evolution will happen. It has no choice, it is inevitable. But the exciting thing is that evolution doesn't care what those self-replicating things are made from.

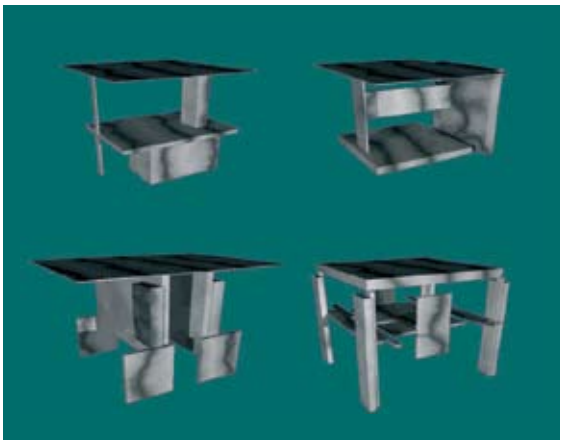
In biology it's all about the genes. When parents have children, the kids inherit their parents' genes. When a mutation happens, that's a random change to a gene. When an organism dies, its genes are lost to future generations unless it managed to have children first. Genes are nothing more than molecular information. Data written into DNA, rather than on a CD-ROM or DVD. But it's all data nonetheless.

In computer science we don't use DNA to store information. Computers are very good at handling information in their electronics rather than in a bag of chemicals. So when I make a virtual world and I drop in those self-replicating things, all I've done is add packets of information that enjoy making copies of themselves. Each packet of information corresponds to a virtual critter – something that exists and interacts with the virtual world. If it's good enough it may survive long enough to make a few copies, if not, it won't. And so generation by generation, the packets of information evolve.

The evolving table

For example, let's say I was evolving a coffee table. Each packet of information represents a possible table design. Some are great, but some are bad, looking more like a pile of bricks or a giant screwed-up ball of paper. Each design can be judged – how well does it function as a table? (Does it support objects at a consistent height without falling over? Is it the right size while being light enough to move?) The better designs have 'children' – new designs which inherit a random mix of the parameter values that make up the parents, plus a little random variation. The worse designs are removed from the population. So each generation

contains table designs only derived from the best of the previous generation. After a few hundred generations, we have a very good evolved coffee table design.



Four coffee table designs – but which will prove to be the fittest?

Even though I may have created the virtual world, and the first simple self-replicating packet of information, I have no idea exactly what it will become. So every time I ask it to evolve a new coffee table, I will see a new design that solves the problem in a different way.

Perhaps you're thinking: evolution is surely enormously slow. But speed is relative. Elephants take a long time to get around to having kids, so their generations last a while. They evolve slowly. Bacteria and viruses reproduce in minutes, not years, which is why we are forever catching the flu and colds – they keep evolving into new varieties every few months. Bacteria are quick, but computers are *much* faster. A computer can have a population of millions of packets of information, with each generation lasting a tiny fraction of a second. We can see the entire evolutionary history of an artificial organism in seconds.

So computers can evolve information (and coffee tables), and information is used for *everything*. You want to compose a piece of music? That's just mp3 data. An image is just a jpeg file. You want to draw a design for something, make a timetable, figure out how to maximise your cash? All just data, so we can evolve it all! We can evolve music, art, designs, timetables, schedules, financial plans. We can evolve brains and bodies of robots, better components for engines. We can even evolve new computers!

I'm a computer scientist at UCL and, like several hundred other scientists around the world, I evolve solutions to problems every day. My furniture at home was evolved by my computer. I've evolved music and art. I've evolved designs for new electronic circuits, robots, hospital designs. I'm no good at creating any of those things – I just tell my computer what I want and it evolves it for me.

So if Darwin was sitting next to me I'd be able to explain this to him. His theory of evolution is not just a theory any more. It's a technology. We exploit it every day for an astonishing variety of products, including my coffee table. Darwin is going to stay famous for a long time, and rightly so.

Dr Peter J Bentley *is a senior research fellow at University College London and author of* The Undercover Scientist *and* The Book of Numbers. *His website is at http://www.peterjbentley.com*

Australia's new flowers

Jon McCormack is an Australian artist and computer scientist. He has written the software which evolves the striking virtual flowers which you see here. You can see more of his work at www.csse.monash.edu.au/~jonmc/art.html.

Jon McCormack's works in a street installation at Queensland University of Technology